IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

SPRINT COMMUNICATIONS COMPANY L.P., Plaintiff, v. WIDEOPENWEST, INC., WIDEOPENWEST NETWORKS, INC., AND WIDEOPENWEST FINANCE, LLC, WIDEOPENWEST GEORGIA, LLC, KNOLOGY OF ALABAMA, INC., KNOLOGY OF FLORIDA, LLC, KNOLOGY OF GEORGIA, INC., KNOLOGY OF SOUTH CAROLINA, INC., KNOLOGY OF TENNESSEE, INC., KNOLOGY OF KANSAS, INC., AND ANNE ARUNDEL BROADBAND, LLC, Defendants.	)	Case No. 18-361-RGA **JURY TRIAL DEMANDED**

SECOND AMENDED COMPLAINT

Plaintiff Sprint Communications Company L.P. complains as follows against Defendants WideOpenWest, Inc., WideOpenWest Networks, Inc., WideOpenWest Finance, LLC, WideOpenWest Georgia, LLC, Knology of Alabama, Inc., Knology of Florida, LLC, Knology of Georgia, Inc., Knology of South Carolina, Inc., Knology of Tennessee, Inc., Knology of Kansas, Inc., and Anne Arundel Broadband, LLC (collectively, “WOW” or “Defendants”).

PARTIES

1. Plaintiff Sprint Communications Company L.P. (“Sprint”) is a limited partnership organized and existing under the laws of the State of Delaware, with its principal place of business at 6200 Sprint Parkway, Overland Park, Kansas 66251.

2. On information and belief, Defendant WideOpenWest, Inc. is a company organized and existing under the laws of the State of Delaware, with its principal place of business at 7887

East Belleview Avenue, Suite 1000, Englewood, Colorado 80111.

3. On information and belief, Defendant WideOpenWest Networks, Inc. is a company organized and existing under the laws of the State of Delaware, with its principal place of business at 7887 East Belleview Avenue, Suite 1000, Englewood, Colorado 80111.

4. On information and belief, Defendant WideOpenWest Finance, LLC is a limited liability company organized and existing under the laws of the State of Delaware, with its principal place of business at 7887 East Belleview Avenue, Suite 1000, Englewood, Colorado 80111.

5. On information and belief, Defendant WideOpenWest Georgia, LLC is a limited liability company organized and existing under the laws of the State of Delaware, with its principal place of business at 7887 East Belleview Avenue, Suite 1000, Englewood, Colorado 80111.

6. On information and belief, Defendant Knology of Alabama, Inc. is a company organized and existing under the laws of the State of Delaware, with its principal place of business at 1241 O.G. Skinner Drive, West Point, Georgia 31833.

7. On information and belief, Defendant Knology of Florida, LLC is a limited liability company organized and existing under the laws of the State of Delaware, with its principal place of business at 1241 O.G. Skinner Drive, West Point, Georgia 31833.

8. On information and belief, Defendant Knology of Georgia, Inc. is a company organized and existing under the laws of the State of Delaware, with its principal place of business at 1241 O.G. Skinner Drive, West Point, Georgia 31833.

9. On information and belief, Defendant Knology of South Carolina, Inc. is a company organized and existing under the laws of the State of Delaware, with its principal place of business at 1241 O.G. Skinner Drive, West Point, Georgia 31833.

10. On information and belief, Defendant Knology of Tennessee, Inc. is a company

organized and existing under the laws of the State of Delaware, with its principal place of business at 1241 O.G. Skinner Drive, West Point, Georgia 31833.

11. On information and belief, Defendant Knology of Kansas, Inc. is a company organized and existing under the laws of the State of Delaware, with its principal place of business at 1241 O.G. Skinner Drive, West Point, Georgia 31833.

12. On information and belief, Defendant Anne Arundel Broadband, LLC is a limited liability company organized and existing under the laws of the State of Delaware, with its principal place of business at 406 Headquarters Drive, Suite 201, Millersville, Maryland 21108.

13. On information and belief, each Defendant currently does and has in the past provided or participated in providing broadband and/or packet-based telephony products or services, including, but not limited to, WOW! Phone, WOW! Business Voice, and other related digital telephony services.

JURISDICTION

14. This is an action for patent infringement under the United States Patent Laws, 35 U.S.C. § 271, *et. seq.* This Court has subject matter jurisdiction over this action under 28 U.S.C. §§ 1331 and 1338.

15. This Court has personal jurisdiction over Defendants because they are incorporated in the State of Delaware and therefore may be fairly regarded as at home in this Judicial District.

VENUE

16. Venue is proper in this Court pursuant to 28 U.S.C. § 1400(b). Defendants are incorporated in the State of Delaware and therefore reside in this Judicial District pursuant to 28 U.S.C. § 1400(b).

JOINDER

17. Joinder of Defendants is proper under 35 U.S.C. § 299. The allegations of patent

infringement contained herein arise out of the same series of transactions or occurrences relating to the making, using, offering for sale, and/or selling within the United States, and/or importing into the United States, of the same accused products and services.

18. Common questions of fact relating to Defendants' infringement will arise in this action, as well as questions regarding Defendants' damages owed to Sprint.

FACTUAL BACKGROUND

Sprint's Voice-over-Packet ("VoP") Technology

19. In 1993, Sprint's leading technology specialists and engineers were attempting to solve a very important problem affecting Sprint's ability to expand its network to support its rapidly growing customer base. At that time, virtually all voice traffic was carried over the Public Switched Telephone Network ("PSTN"), which utilized highly complex, extremely expensive switches and other well-established components to route this traffic. One solution to Sprint's problem—a solution that Sprint had used in the past—was to simply purchase additional switches from the legacy manufacturers and install those in its network. Adding switches, however, was extremely expensive and time consuming because Sprint's entire network of switches would have to be reprogrammed for each switch addition or upgrade. In addition, voice traffic on the PSTN was transported using inherently inefficient synchronous circuit-switching. A circuit was reserved for the entire length of a call on the PSTN, which wasted significant bandwidth during periods of time when no conversation was occurring. But legacy circuit-based systems had long been widely used to carry voice communications, and there were no viable alternatives in the marketplace available to Sprint or other carriers at the time.

20. One of Sprint's talented technologists, Joe Christie, observed that data communications between computers were handled differently. Computers communicated with each other using "packets" of data. Packet communications, unlike the synchronous

communications of the PSTN, could occur "asynchronously" where the sending and receiving points could send and receive out of synch with each other. This created an opportunity to realize substantial efficiencies by transmitting voice data packets only when there is voice data to send and refraining from wasting valuable bandwidth during periods of silence. In addition, unlike the complex and expensive switches used in the PSTN, data packets could be routed using fairly inexpensive components that could be made available from a number of competing vendors. Unfortunately, the two systems were not compatible with each other. Interfacing a circuit-switched system with a packet-based system in a geographically expansive telecommunications environment was not a reality, at least not before Joe Christie.

21. Joe Christie was an expert in two dissimilar technologies: packet-based networks and SS7 signaling (which was used by the PSTN to set up voice calls). Mr. Christie proposed a solution that would ultimately revolutionize the telecommunications industry. He devised a way to leverage the efficiencies of packet-based networks to make telephone calls to and from the PSTN. To do so, Mr. Christie invented a series of architectures, components, and processes that would allow the PSTN to "talk" to packet-based networks to set up and route telephone calls across these disparate networks in a seamless and transparent manner. These calls were highly efficient and substantially decreased the need for telephone companies to rely on expensive legacy PSTN equipment.

22. Mr. Christie's Voice-over-Packet ("VoP") technology reduced or eliminated the need for service providers to rely on conventional switches and switch-to-switch call processing. Instead, Mr. Christie conceived of centralizing network control by using a call processor to orchestrate calls over his new packet-based system. The call processor acted like the brains of the network, determining where a call needed to go and then enabling routing to its destination. This

call processor extracted the intelligence of expensive and complicated legacy switches and placed this intelligence on functionally separate computer platforms. By extracting call control from the switch manufacturers, Mr. Christie allowed a host of competitors to provide processing equipment and to get into the business of telephony. This innovation would eventually increase competition, drive down the costs of telephony, and greatly improve efficiency.

23. When Mr. Christie presented his innovations to Sprint executives and Sprint technical management, they recognized the importance of his innovations. Mr. Christie's inventions had the potential to render obsolete major components within the PSTN and to break the grip that switch manufacturers held on carriers and service providers. Mr. Christie's innovations could dramatically alter the way telephone calls were made and change the landscape of the relative strength and leverage of the players in the industry. They represented a sea change in telephony, and Mr. Christie's colleagues at Sprint, including upper-level executives, realized it. Sprint promptly assigned a patent agent to shadow Mr. Christie to learn as much as possible about the various aspects of his new systems and to seek patent protection. Sprint also assigned a team of some of Sprint's most talented engineers to work with Mr. Christie and to help develop concepts into tangible platforms. Due to the highly sensitive nature of the project, the team was sequestered in a Kansas City facility and instructed to maintain the project in the strictest of confidence. Few people in Sprint knew of this project at the time.

24. Joe Christie died unexpectedly in his home in February of 1996. Mr. Christie did not live to see his innovations deployed into a commercial platform. But Mr. Christie's revolutionary inventions have an enduring legacy. Mr. Christie's inventions and the related innovations made by people working with Mr. Christie have resulted in a VoP patent portfolio of over 120 issued United States Patents. Unfortunately, many companies in the industry, including

WOW, have realized the great value in this technology and have misappropriated it without Sprint's permission. It is because of this unauthorized use that Sprint has taken efforts to enforce this patent portfolio against others in the industry in the past and is now enforcing its patents in this case.

Sprint's Enforcement Efforts and Licenses

25. In 2007, in the matter styled *Sprint Communications Co. L.P. v. Vonage Holdings Corp. et al.*, Case No. 05-2433-JWL (D. Kan.), a Kansas jury found that Vonage Holdings Corp. and Vonage America, Inc. ("Vonage") had willfully infringed six patents contained in this portfolio, including patents that are at issue in this case, found that the six patents were valid, assessed a five percent (5 %) reasonable royalty, and awarded Sprint $69.5 million in damages. Following the verdict, Vonage entered a settlement agreement with Sprint whereby Vonage paid Sprint $80 million for a license to Sprint's VoP portfolio. Previously, in that same matter, tglo.com, Inc. (formerly known as VoiceGlo Holdings, Inc.) and Theglobe.com Inc. ("VoiceGlo") had entered a settlement agreement in which VoiceGlo licensed Sprint's VoP patents.

26. In 2008, Sprint again sued to enforce patents from its VoP portfolio in additional lawsuits against companies engaging in the unauthorized use of Sprint's VoP technology: *Sprint Communications Co. L.P. v. Paetec Holding Corp. et al.*, Case No. 08-cv-2044-JWL/GLR (D. Kan.), *Sprint Communications Co. L.P. v. Broadvox Holdings, LLC et al.*, Case No. 08-cv-2045-JWL/DJW (D. Kan.); *Sprint Communications Co. L.P. v. Big River Telephone Co., LLC*, Case No. 08-cv-2046-JWL/DJW (D. Kan.), and *Sprint Communications Co. L.P. v. Nuvox, Inc. et al.*, Case No. 08-cv-2047-JWL/JPO (D. Kan.). By late 2009, Sprint had entered settlement agreements resolving these lawsuits and, as a result, a number of additional companies licensed patents from Sprint's VoP portfolio.

27. During this same time frame, Sprint continued to derive substantial revenues from providing numerous cable companies with a network backbone to carry voice traffic to support those companies' digital telephone offerings, which use packet networks coupled with the PSTN.

28. In 2011, Sprint again sued to enforce patents from its VoP portfolio for the unauthorized use of its patented technology: *Sprint Communications Co. L.P. v. Cox Communications, Inc., et al.*, Case No. 11-cv-2683-JWL (D. Kan.), *Sprint Communications Co. L.P. v. Comcast Cable Communications, LLC et al.*, Case No. 11-cv-2684-JWL (D. Kan.), *Sprint Communications Co. L.P. v. Cable One, Inc.*, Case No. 11-cv-2685-JWL (D. Kan.), and *Sprint Communications Co. L.P. v. Time Warner Cable Inc., et al.*, Case No. 11-cv-2686-JWL (D. Kan.). In 2016, Sprint entered into a settlement agreement resolving the Cable One lawsuit. In March 2017, a Kansas jury found that Time Warner Cable had willfully infringed five patents in this portfolio, including patents that are at-issue in this case, awarding Sprint $139.8 million in damages. Subsequently, in 2017, Sprint entered into settlement agreements resolving the Comcast lawsuit and the Cox lawsuit.

The Patents-In-Suit

29. Plaintiff Sprint is the owner by assignment of all right, title, and interest in and to United States Patent No. 6,343,084 ("the '084 Patent") entitled "Broadband Telecommunications System," which duly and legally issued in the name of Joseph Michael Christie on January 29, 2002. A copy of the '084 Patent is attached to the Complaint as Exhibit A.

30. Plaintiff Sprint is the owner by assignment of all right, title, and interest in and to United States Patent No. 6,633,561 ("the '3,561 Patent") entitled "Method, System and Apparatus for Telecommunications Control," which duly and legally issued in the name of Joseph Michael Christie on October 14, 2003. A copy of the '3,561 Patent is attached to the Complaint as Exhibit B.

31. Plaintiff Sprint is the owner by assignment of all right, title, and interest in and to United States Patent No. 6,463,052 ("the '052 Patent") entitled "Method, System and Apparatus for Telecommunications Control," which duly and legally issued in the name of Joseph Michael Christie on October 8, 2002. A copy of the '052 Patent is attached to the Complaint as Exhibit C.

32. Plaintiff Sprint is the owner by assignment of all right, title, and interest in and to United States Patent No. 6,452,932 ("the '932 Patent") entitled "Method, System and Apparatus for Telecommunications Control," which duly and legally issued in the name of Joseph Michael Christie on September 17, 2002. A copy of the '932 Patent is attached to the Complaint as Exhibit D.

33. Plaintiff Sprint is the owner by assignment of all right, title, and interest in and to United States Patent No. 6,473,429 ("the '429 Patent") entitled "Broadband Telecommunications System," which duly and legally issued in the name of Joseph Michael Christie on October 29, 2002. A copy of the '429 Patent is attached to the Complaint as Exhibit E.

34. Plaintiff Sprint is the owner by assignment of all right, title, and interest in and to United States Patent No. 6,298,064 ("the '064 Patent") entitled "Broadband Telecommunications System," which duly and legally issued in the name of Joseph Michael Christie on October 2, 2001. A copy of the '064 Patent is attached to the Complaint as Exhibit F.

35. Plaintiff Sprint is the owner by assignment of all right, title, and interest in and to United States Patent No. 6,330,224 ("the '224 Patent") entitled "System and Method for Providing Enhanced Services for a Telecommunication Call," which duly and legally issued in the names of Joseph Michael Christie, Joseph S. Christie, and Tracy Lee Nelson on December 11, 2001. A copy of the '224 Patent is attached to the Complaint as Exhibit G.

36. Plaintiff Sprint is the owner by assignment of all right, title, and interest in and to United States Patent No. 6,697,340 ("the '340 Patent") entitled "System and Method for Providing Enhanced Services for a Telecommunication Call," which duly and legally issued in the names of Joseph Michael Christie, Joseph S. Christie, Jean M. Christie, and Tracy Lee Nelson on February 24, 2004. A copy of the '340 Patent is attached to the Complaint as Exhibit H.

37. Plaintiff Sprint is the owner by assignment of all right, title, and interest in and to United States Patent No. 7,286,561 ("the '6,561 Patent") entitled "Method System and Apparatus for Telecommunications Control," which duly and legally issued in the name of Joseph Michael Christie on October 23, 2007. A copy of the '6,561 Patent is attached to the Complaint as Exhibit I.

38. Plaintiff Sprint is the owner by assignment of all right, title, and interest in and to United States Patent No. 7,505,454 ("the '454 Patent") entitled "Method, System and Apparatus for Telecommunications Control," which duly and legally issued in the name of Joseph Michael Christie on March 17, 2009. A copy of the '454 Patent is attached to the Complaint as Exhibit J.

39. Plaintiff Sprint is the owner by assignment of all right, title, and interest in and to United States Patent No. 7,327,728 ("the '728 Patent") entitled "Broadband Telecommunications System," which duly and legally issued in the name of Joseph Michael Christie, Albert D. Duree, Michael Joseph Gardner, William Lyle Wiley, Manu Chand Bahl and Daniel Charles Sbisa on February 5, 2008. A copy of the '728 Patent is attached to the Complaint as Exhibit K.

40. Plaintiff Sprint is the owner by assignment of all right, title, and interest in and to United States Patent No. 7,324,534 ("the '534 Patent") entitled "Broadband Telecommunications System Interface," which duly and legally issued in the name of Joseph Michael Christie, Michael Joseph Gardner, Tracy Lee Nelson, William Lyle Wiley and Albert Daniel Duree on January 29, 2008. A copy of the '534 Patent is attached to the Complaint as Exhibit L.

41. Plaintiff Sprint is the owner by assignment of all right, title, and interest in and to United States Patent No. 7,693,131 ("the '131 Patent") entitled "Telecommunications System to Provide Analog Telephony Communications Over a Packet Connection," which duly and legally issued in the name of Martin Joseph Kaplan, Frank Anthony DeNap, John Arndt Strand, III, William Lee Edwards, Bryan Lee Gorman, Murat Bog, Michael Thomas Swink and Harold Wayne Johnson on April 6, 2010. A copy of the '131 Patent is attached to the Complaint as Exhibit M.

42. Plaintiff Sprint is the owner by assignment of all right, title, and interest in and to United States Patent No. 6,563,918 ("the '918 Patent") entitled "Telecommunications System Architecture for Connecting a Call," which duly and legally issued in the name of Tracy Lee Nelson, William Lyle Wiley, Royal Dean Howell, Michael Joseph Gardner and Albert Daniel DuRee on May 13, 2003. A copy of the '918 Patent is attached to the Complaint as Exhibit N.

43. Plaintiff Sprint is the owner by assignment of all right, title, and interest in and to United States Patent No. 6,999,463 ("the '463 Patent") entitled "Number Portability In A Communications System," which duly and legally issued in the name of Joseph Michael Christie, Joseph S. Christie, Jean M. Christie, Michael Joseph Gardner, Albert Daniel Duree, William Lyle Wiley, and Tracy Lee Nelson on February 14, 2006. A copy of the '463 Patent is attached to the Complaint as Exhibit O.

44. The patents identified in paragraphs 29–43 and attached as Exhibits A–O are herein collectively referred to as "Sprint's Patents" or the "Asserted Patents."

WOW

45. Upon information and belief, Defendants operate collectively as a single operating unit, WOW, under the direction and control of parent companies WideOpenWest, Inc. and WideOpenWest Finance, LLC. For example, on information and belief, all Defendants share the same principal office addresses, the same corporate phone number, and the same website. Upon

further information and belief, at relevant times, all Defendants have had substantial overlap with each other in their executive officers with substantially the same team of officers continuing to serve during the relevant times. WideOpenWest, Inc. and WideOpenWest Finance, LLC each also claims to have received the same awards, each identifying itself as "WOW!" in public filings.[1]

46. Upon information and belief, WideOpenWest, Inc. is the direct parent of both WideOpenWest Finance, LLC and WideOpenWest Networks, Inc. Upon further information and belief, WideOpenWest Georgia, LLC, Knology of Alabama, Inc., Knology of Florida, LLC, Knology of Georgia, Inc., Knology of Kansas, Inc., Knology of South Carolina, Inc., Knology of Tennessee, Inc., and Anne Arundel Broadband, LLC (collectively, "the WOW Subsidiaries") are each direct or indirect subsidiaries of WideOpenWest Finance, LLC.

47. Upon information and belief, Defendants and their subsidiaries hold themselves out to the public as a single company that operates under the same trade names and provides the same phone, data, and cable services to each of their subscribers across various geographic regions.[2] For instance, Defendants and their subsidiaries each do business as "d/b/a WOW! Internet, Cable and Phone" and represent themselves as a single entity that provides the Accused Products and Services to customers across at least 19 regional markets.[3]

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[1] *See, e.g.*, WideOpenWest Finance, LLC, Annual Report (Form 10-K) (2014) at p. 1 ("For example, WOW has been recognized by Consumer Reports Magazine (#1 U.S. cable provider for five out of the last six years), PC Magazine and J.D. Power and Associates (highest customer satisfaction 19 times in the last 10 years)."); WideOpenWest, Inc., Annual Report (Form 10-K) (2017) at p. 4. ("For example, WOW has been recognized by Consumer Reports Magazine (rated highest across several categories 15 times in the last 9 years) and J.D. Power and Associates (highest customer satisfaction 21 times in the last 13 years).").

[2] *See* WideOpenWest, Inc., Annual Report (2018) at pp. 2-3; *UBS 46th Annual Telecom and Media Conference*, presented by CEO Theresa Elder on December 4, 2018 (https://s22.q4cdn.com/999869821/files/doc_presentations/UBS-Dec-2018-Conference-vF.pdf); DMCA Designated Agent Directory for WideOpenWest Finance, LLC, (https://dmca.copyright.gov/osp/publish/history.html?search=wow!&id=b936ca38ca93c97c6dd872398d428978) (last visited June 26, 2019).

[3] *See, e.g.*, https://www.wowway.com/docs/wow/documents-terms-and-conditions/internet-terms-south.pdf ("[T]he Subscriber Agreement and Terms and Conditions set forth below apply to WOW!'s residential customers located in the following operating regions: Illinois, Indiana,

48. Upon information and belief, WOW is the sixth largest cable operator in the United States, providing high-speed data, cable television, Voice over IP-based telephony and business-class services to a service area that includes approximately 3.0 million homes and businesses. *See* WideOpenWest, Inc. – Investor Relations, http://ir.wowway.com/investor-relations/overview (last visited June 7, 2019). Upon information and belief, WOW has approximately 807,900 customers who subscribe to its services. *See id.*

49. Upon information and belief, each Defendant has made, used, offered to sell, and/or sold, and continues to make, use, offer to sell, and/or sell broadband and/or packet-based telephony products or services, including, but not limited to, WOW! Phone, WOW! Business Voice, and other related telephony services (collectively, the "Accused Products and Services"), without Sprint's permission. Defendants have each committed infringing activities by providing the Accused Products and Services. For example, WideOpenWest, Inc. and WideOpenWest Finance, LLC each admits that it installs a network interface box outside an end-user's home or an Embedded Multimedia Terminal Adapter inside the end-user's home and provides telephony service "using Voice over Internet Protocol ('VoIP') switching technology."[4]

Michigan, Ohio, Alabama, Florida, Georgia, South Carolina, and Tennessee. We refer to the operating company subsidiary of WideOpenWest Finance, LLC d/b/a WOW! Internet, Cable and Phone . . . that provides phone and/or Internet service in your area as "WOW!," "Knology," "we," "us," or "our.") (last visited June 26, 2019); https://ir.wowway.com/investor-relations/news/press-release-details/2018/WOW-Brings-Affordability-Back-to-the-Landline-Phone/default.aspx ("WOW! Internet, Cable & Phone . . . provides service in 19 markets, primarily in the Midwest and Southeast, . . . including high-speed Internet services, cable TV, phone, business data, voice, and cloud services.") (last visited June 26, 2019); https://www.fcc.gov/document/application-sigecom-llc-dba-wow-internet-cable-and-phone-0 ("Sigecom, LLC d/b/a WOW! Internet, Cable and Phone") (last visited June 26, 2019); https://ir.wowway.com/investor-relations/news/press-release-details/2018/WOW-To-Present-at-The-UBS-46th-Annual-Global-Media--Communications-Conference/default.aspx ("WOW! Internet, Cable & Phone ('WOW!' or the 'Company') (NYSE: WOW), a leading fully integrated provider of residential and commercial high-speed data, video and telephony services to customers in the United States.") (last visited June 27, 2019).

[4] *See* WideOpenWest Finance, LLC, Annual Report (Form 10-K) (2014) at p. 8; WideOpenWest, Inc., Annual Report (Form 10-K) (2017) at p. 12.

50. On information and belief, each Defendant has had knowledge of one or more of the Asserted Patents and the infringing nature of its products since at least 2007. For instance, on or around December 17, 2007, Sprint notified the Defendants that Sprint has a portfolio of over 120 U.S. voice over packet patents and that Sprint recently obtained a patent infringement verdict against Vonage's VoIP telephony product based on a rate of 5% of Vonage's revenue.[5] Sprint also explained that companies seeking to offer telecommunications products and services in the field related to telecommunications between packet-based networks and narrowband systems would very likely need Sprint's permission by way of a license agreement. Also on information and belief, Sprint notified the Defendants in the same letter that Sprint would aggressively enforce its intellectual property against all unauthorized use.

51. Defendants' knowledge of certain of the Asserted Patents notwithstanding, each Defendant continued to make, use, sell, and/or offer for sale its products and services that infringe Sprint's intellectual property, all despite an objectively high likelihood that their actions constituted infringement of one or more valid patents. Upon information and belief, each Defendant either knew or should have known of such infringement of Sprint's intellectual property rights.

The Accused Products and Services

52. On information and belief, each Defendant has made, used, offered to sell, and/or sold and continues to make, use, sell, and/or offer to sell the Accused Products and Services within the United States. On information and belief, each Defendant's Accused Products and Services

[5] On information and belief, WOW operated under a different name and structure at the time it received notice of Sprint's patent portfolio but has since restructured. *See* WideOpenWest, Inc., Annual Report (Form 10-K) (2017) at pp. 5, F-7. On information and belief, the WOW entities who received notice of Sprint's patent portfolio in 2007 were comprised of and included the now-existing WOW entities named as Defendants in this Complaint.

have provided, and continue to provide, functionality that allows voice and/or data information to be transmitted over a packet communication system connected to the PSTN. On information and belief, the Accused Products and Services accomplish communication control through a processing system that processes signaling to select network characteristics and signals network elements based on the selections.

A. On information and belief, WideOpenWest Finance, LLC owns, rents, contracts for, or otherwise controls the operation of the network equipment used to provide the Accused Products and Services. For each and every item of equipment described in ¶¶ 55-77 that WideOpenWest Finance, LLC does not itself directly operate, WideOpenWest Finance, LLC directs and controls the operation of the equipment in the manner described in those paragraphs. For example, to the extent WideOpenWest Finance, LLC does not itself operate a media gateway, WideOpenWest Finance, LLC directs a third-party (e.g., each of one or more of the WOW Subsidiaries, another subsidiary d/b/a "WOW! Internet, Cable and Phone," and/or another third party) to operate one or more media gateways in the manner described in the allegations in ¶¶ 55-77 that pertain to media gateways, with the third party contractually obligated to operate such equipment in a way that ensures communications are received, processed and sent in the manner described in ¶¶ 55-77. The allegations in this paragraph are supported, at least, by the fact that WideOpenWest Finance, LLC implements PacketCable to provide telephony services, which require the equipment and call flows specified below.

B. In the alternative and on information and belief, WideOpenWest Networks, Inc. owns, rents, contracts for, or otherwise controls the operation of the network equipment described in ¶¶ 55-77. For each and every item of equipment described in ¶¶ 55-77 that WideOpenWest Networks, Inc. does not itself directly operate, WideOpenWest Networks, Inc. directs and controls the operation of the equipment in the manner described in those paragraphs. For example, to the extent WideOpenWest Networks, Inc. does not itself operate a media gateway, WideOpenWest Networks, Inc. directs a third-party (e.g., each of one or more of the WOW Subsidiaries, another subsidiary d/b/a "WOW! Internet, Cable and Phone," and/or another third party) to operate one or more media gateways in the manner described in the allegations in ¶¶ 55-77 that pertain to media gateways, with the third party contractually obligated to operate such equipment in a way that ensures communications are received, processed and sent in the manner described in ¶¶ 55-77. The allegations in this paragraph are supported, at least, by the fact that WideOpenWest Networks, Inc. implements PacketCable to provide telephony services, which require the equipment and call flows specified below.

C. In the alternative and on information and belief, WideOpenWest, Inc. owns, rents, contracts for, or otherwise controls the operation of the network equipment described in ¶¶ 55-77. For each and every item of equipment described in ¶¶ 55-77 that WideOpenWest, Inc. does not itself directly operate, WideOpenWest, Inc. directs and controls the operation of the equipment in the manner described in those paragraphs. For example, to the extent WideOpenWest, Inc. does not itself operate a media gateway, WideOpenWest, Inc. directs a third-party (e.g., each of one or more of the WOW Subsidiaries, another subsidiary d/b/a "WOW! Internet, Cable and Phone," WideOpenWest Finance, Inc., and/or another third party) to operate one or more media gateways in the manner described in the allegations in ¶¶ 55-77 that pertain to media gateways, with the third party contractually obligated to operate such equipment in a way that ensures communications are received, processed and sent in the manner described in ¶¶ 55-77. The allegations in this paragraph are supported, at least, by the fact that WideOpenWest, Inc. implements PacketCable to provide telephony services, which require the equipment and call flows specified below.

D. In the alternative and on information and belief, each of one or more of the WOW Subsidiaries owns, rents, contracts for, or otherwise controls the operation of the network equipment described in ¶¶ 55-77. For each and every item of equipment described in ¶¶ 55-77 that each of one or more of the WOW Subsidiaries does not itself directly operate, it directs and controls the operation of the equipment in the manner described in those paragraphs. For example, to the extent each of one or more of the WOW Subsidiaries does not itself operate a media gateway, it directs a third-party (e.g., each of one or more of the other WOW Subsidiaries, another subsidiary d/b/a "WOW! Internet, Cable and Phone," and/or another third party) to operate one or more media gateways in the manner described in the allegations in ¶¶ 55-77 that pertain to media gateways, with the third party contractually obligated to operate such equipment in a way that ensures communications are received, processed and sent in the manner described in ¶¶ 55-77. The allegations in this paragraph are supported, at least, by the fact that each of one or more of the WOW Subsidiaries implements PacketCable to provide telephony services, which require the equipment and call flows specified below.

53. In particular, on information and belief, each Defendant's voice services make use of one or more PacketCable-compliant softswitches (e.g., a Nortel CS2000) for performing call processing functions, including routing through and control of one or more media gateways having Digital Signal Processing agents for interworking voice user communications between TDM and IP formats and/or others. Further, on information and belief, each Defendant provided and still provides VoIP telephony services that are capable of placing calls to, and receiving calls from, the

PSTN. These services were and are provided through devices operating on WOW's network, including network elements that are dedicated to call control and set-up (e.g., a softswitch such as the Nortel CS2000), as well as interworking between packet-based/broadband formats and time-based/narrowband formats (e.g., media gateways). In particular, each Defendant has provided and continue to provide, to its VoIP subscribers, an IP-based, broadband connection between appropriate customer premises equipment (e.g., a Multimedia Terminal Adapter ("MTA")) and one or more softswitches for communicating call signaling using NCS protocols, as specified by Cable Television Laboratories, Inc. (CableLabs®).

54. On further information and belief, each Defendant makes use of media gateways and softswitches that are PacketCable compliant.[6] Accordingly, each Defendant uses, or contracts with a third party who uses, equipment that practices all of the applicable PacketCable specification defined by CableLabs®.

—Inbound Calls—
A Call From The PSTN To A VoIP Subscriber Through A Media Gateway[7]

55. On information and belief, during an Inbound Call, a softswitch used by or on behalf of each Defendant (hereinafter collectively referred to as a "Call Management Server" or "CMS"),[8] receives an SS7 Initial Address Message ("IAM") from a PSTN signaling point. The

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[6] *See e.g.*, Am. Compl. ¶ 21, *Charter Communications Inc.* et al v. *Rockstar Consortium US LP* et al, 1:14CV00055 (D. Del. June 13, 2014) (No. 53) ("WideOpenWest and Knology use equipment that complies with . . . PacketCable 1.5.").

[7] While the call flows in the paragraphs 55-77 are in the present tense, on information and belief, each Defendant performed these call flows in the past, including during and prior to 2014.

[8] For brevity, Sprint identifies a CMS. However, a Defendant's VoP network may include other components, or connect to components operated third parties on each Defendant's behalf, such as a Media Gateway Controller ("MGC"), a Signaling Gateway ("SG"), and/or a Call Agent ("CA") or IP Multimedia Subsystem ("IMS") equivalents, that perform analogous functions in some instances as a CMS. Further, on information and belief, IMS implementations include Call Session Control Function ("CSCF"), which perform analogous functions to Call Management Servers and Call Agents; Media Gateway Controller Function ("MGCF"), which perform analogous functions to Media Gateway Controllers; and Signaling Gateways ("SGW"), which perform analogous

SS7 message is received over A- or D-links in SS7 or SIGTRAN format. The received SS7 IAM message includes, amongst other things, a Destination Point Code ("DPC"), an Origination Point Code ("OPC"), a Circuit Identification Code ("CIC"), the calling party's telephone number, the called party's telephone number (i.e., the dialed telephone number), and, if applicable, a Location Routing Number ("LRN") associated with the called party's telephone number.

56. On further information and belief, each Defendant's CMS processes information in the SS7 IAM message to make selections with respect to establishing and routing the call. For example, on information and belief, the Defendant's CMS uses, amongst other things, the OPC and CIC information included in the SS7 IAM to identify a Media Gateway ("MG") that is used to interwork bearer traffic (i.e., speech or voice on the call) between TDM and packet-based formats. Likewise, the Defendant's CMS also uses, amongst other things, the telephone number and/or LRN included in the SS7 IAM to identify the called party, including an IP address associated with the called party's Media Terminal Adapter ("MTA"). These selections, as well as others, are based on call routing data stored within the Defendant's CMS in call routing database tables that are populated by one or more Element Management Systems ("EMS") used by WOW.

57. On information and belief, during an Inbound Call, a Defendant's CMS sends a CRCX (create connection message) to the MG instructing the MG to create a session in inactive mode. On information and belief, an MG operated by or on behalf of the Defendant creates the session in inactive mode and responds to the CRCX message with an acknowledgment message,

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functions to Signaling Gateways. *See, e.g.*, PacketCable 2.0 Architecture Framework Technical Report at pp. 7-12 (https://community.cablelabs.com/wiki/plugins/servlet/cablelabs/alfresco/download?id=be851709-5acb-42d3-ba34-3d378140da29); 3rd Generation Partnership Project Technical Specification Group Services and Systems Aspects IP Multimedia Subsystem (IMS) Stage 2 (Release 7) at p. 18 (http://www.3gpp.org/ftp/Specs/archive/23_series/23.228/23228-700.zip).

which includes the MG's Session Description Protocol ("SDP") profile information. On information and belief, the SDP profile includes, among other information, the IP address and port of the MG to which voice information will be sent using Real-time Protocol ("RTP") voice packets.

58. On information and belief, during an Inbound Call, a Defendant's CMS sends a CRCX message to the MTA instructing the MTA to create a session. On information and belief, the CRCX includes the MG's IP address and port information. On information and belief, a Defendant's MTA sends an ACK (acknowledgement message) in response to the CRCX to the Defendant's CMS that includes the MTA's own SDP profile which includes, among other information, the MTA's IP address and port information. The IP address included in the ACK from the MTA to the Defendant's CMS is the same IP address used by the CMS to send the CRCX message to the MTA instructing the MTA to create a session.

59. On information and belief, during an Inbound Call, when the called party answers the call, the MTA sends a NTFY (notify message) indicating an off-hook event to the Defendant's CMS. The Defendant's CMS sends an MDCX (modify connection message) to the MG instructing the MG to modify the inactive session to become an active session to exchange two-way bearer traffic (i.e., speech or voice traffic) for the call. The MDCX includes the IP address of the MTA identified by the Defendant's CMS and used to communicate the above-described CRCX message to the MTA. The MDCX also includes the port information provided by the MTA in the ACK to the Defendant's CMS.

60. On information and belief, during an Inbound Call, voice information between the MG interfacing with the PSTN is transmitted from the MG to the MTA (and *vice versa*) using RTP. On further information and belief, the MG receives bearer audio from the PSTN (i.e., voice or speech audio) and places portions of the digital audio into the payloads of RTP voice packets.

The bearer audio (i.e., voice or speech audio) is received by the MG from the PSTN over a DS0 connection corresponding to the OPC, DPC, and CIC values included in the SS7 IAM. The bearer audio (i.e., voice or speech audio) is received by the MG at a data rate of 64 kilobits per second, and is not packetized.

61. The MG creates voice packets containing the bearer audio (i.e., voice or speech audio) received over the DS0 connection according to specified packetization period (e.g., 10 milliseconds, 20 milliseconds) using a specified encoding scheme, such as G.711 for Pulse Code Modulation ("PCM"). As a result, on information and belief, all RTP voice packets created for any particular Inbound Call will be of an identical size (e.g., 210 bytes).

62. While creating the RTP voice packets, on information and belief, the MG includes the MTA's IP address received from the Defendant's CMS in the destination field of the RTP voice packets' IP headers. On information and belief, the MG then sends the RTP voice packet to Defendant's IP network to eventually reach the Cable Modem Termination System ("CMTS") that is local to the called party's MTA. The RTP voice packets between the MG and the CMTS are not transmitted according to a shared timing relationship, such as Stratum Level clock that ensures packets are delivered synchronously. On information and belief, the CMTS then sends the RTP voice packet to the MTA over the local coaxial cable network.

63. On further information and belief, the called party's MTA receives the RTP voice packets transmitted by the MG. The MTA removes the bearer traffic (i.e., voice or speech audio) from the RTP packets, transcodes the bearer traffic from digital to analog, and transfers the analog audio in non-packet format to an analog telephone connected to the MTA.

64. On information and belief, during an Inbound Call, an MTA similarly receives analog voice from the analog telephone connected to the MTA, transcodes the voice into digital

format, and places portions of the digital voice into the payloads of RTP voice packets. On information and belief, the MTA puts the MG's IP address received from the Defendant's CMS in the destination address field of the RTP voice packets' IP headers. On information and belief, the MTA then sends the RTP voice packet to its local CMTS via the local coaxial cable network. On information and belief, the CMTS forwards the RTP voice packet to Defendant's IP network to eventually reach the MG.

A Call From The PSTN To Voicemail Through A Media Gateway

65. On information and belief, during an Inbound Call to Voicemail, a call from the PSTN is attempted to be connected to a called party's MTA as detailed above (*see* ¶¶ 55-58). If the called party does not answer the call, either because the called party is already connected to a different call ("call forward, busy") or because the called party is not available ("call forward, no answer"), the CMS forwards the call to voicemail.

66. For example, on information and belief, in a "call forward, no answer" scenario, a Defendant's CMS communicates with the MTA to direct the MTA to ring the called party's phone. If a predetermined number of rings or a predetermined amount of time has elapsed before the called party answers the call, a call forward condition is triggered in the CMS. If the called party has the call forwarding to voicemail feature enabled, the CMS performs additional processing to forward the call to voicemail.

67. On information and belief, the CMS uses internal routing tables and data associated with the called party to determine where the call should be forwarded. On information and belief, upon determining that a "call forward, no answer" scenario is occurring, the call can be forwarded to a voicemail platform associated with a trunk group. On information and belief, the CMS generates a SIP message directed toward the voicemail platform, the SIP message containing, among other data, the dialed digits of the called party. The voicemail platform responds to the

CMS with a 200 OK message which includes the IP address and port information of the voicemail platform. The CMS updates the MG with the IP address and port number of the voicemail platform.

68. On information and belief, after the MG receives updated IP address and port information of the voicemail platform, a call can be established between the voicemail platform and the PSTN calling party via the MG in a manner that is functionally similar to a call connected to a MTA as detailed above (*see* ¶¶ 59-63).

—Outbound Calls—
A Call From A VoIP Subscriber To The PSTN Through A Media Gateway

69. On information and belief, during an Outbound Call, when an analog telephone connected to an MTA is picked up, the MTA sends a NTFY indicating an off-hook event to a Defendant's CMS by sending the message to the MTA's local CMTS through the local coaxial cable network, which the CMTS forwards to the Defendant's CMS. On information and belief, the Defendant's CMS sends an ACK in response to the NTFY and a RQNT (notification request message) instructing the MTA to provide a dial-tone and notify the CMS of dialed digits. On information and belief, after the calling party has dialed digits, the MTA sends a NTFY to the CMS with the dialed digit information.

70. On information and belief, the Defendant's CMS processes information included in the NTFY message, including the dialed digits, according to a defined dial plan, such as a dial plan associated with the calling subscriber and/or least cost routing procedures. The Defendant's CMS processes the dialed digits using call routing data stored in a relational call routing database in the CMS, which, on information and belief, is populated with data from an EMS.

71. On information and belief, during an Outbound Call involving a dialed number that has been ported, Defendant's CMS sends an SS7 IAM to the PSTN with the LRN returned in response to a Local Number Portability ("LNP") query as a called party number, which includes

the actual dialed number in the IAM's Generic Address Parameter ("GAP") field. If the number has not been ported, the dialed digits are used for further call processing by the Defendant's CMS. In either scenario, the Defendant's CMS will identify a trunk to connect the call to the PSTN using the dialed digits and/or an LRN. The selected trunk connects a Defendant's MG, on one side, and a switch on the PSTN, on the other, and has an associated CIC value uniquely identifying the selected trunk between the MG and PSTN switch.

72. Once a trunk is selected, the Defendant's CMS identifies the MG associated with one end of the selected trunk using call routing data stored in relational call routing database tables in the Defendant's CMS. Likewise, on information and belief, the Defendant's CMS identifies a signaling Point Code for the PSTN switch on the other side of the selected trunk based call routing data stored in relational call routing database tables in the Defendant's CMS.

73. Using the DPC of the PSTN switch, on information and belief, the Defendant's CMS will send an SS7 IAM message to the PSTN switch associated with the selected Point Code. In particular, the SS7 IAM includes the PSTN switch Point Code in the Destination Point Code field of the SS7 IAM message, along with the Point Code (OPC) of the Defendant's CMS, the CIC associated with the trunk, and the dialed number and/or LRN. The SS7 IAM is sent over A- or D-links in native SS7 or SIGTRAN formats.

74. On information and belief, during an Outbound Call, Defendant's CMS will send a CRCX instructing the MTA to create a session in inactive mode. On information and belief, in response to the CRCX, the MTA sends an ACK to the CMS and includes its SDP profile in the ACK. On information and belief, the MTA's SDP profile contains, among other information, the MTA's IP address and port information.

75. On information and belief, during an Outbound Call, Defendant's CMS also sends

a CRCX to the selected MG associated with the identified trunk, including the MTA's SDP profile, instructing the MG to create a session. On information and belief, in response to the CRCX the MG creates a session and sends an ACK, which includes the MG's own SDP profile. On information and belief, the MG's SDP profile includes, among other information, the MG's IP address and port number to which the MTA should send RTP voice packets.

76. On information and belief, during an Outbound Call, after the PSTN called party answers the phone, voice information between the calling party's MTA and the MG interfacing with the PSTN is then transmitted from the MTA to the MG (and *vice versa*) using RTP, as generally discussed above (*see* ¶¶ 59–64). On information and belief, the MTA receives analog audio from the connected telephone, transcodes it to digital format, and places portions of the digital audio into the payloads of RTP voice packets. On information and belief, the MTA puts the MG's IP address, which it received from the MG, in the destination address field of the RTP voice packets' IP headers. On information and belief, the MTA then sends the RTP voice packet to its local CMTS via the local coaxial cable network. On information and belief, the CMTS then sends the RTP voice packet to Defendant's IP network where it reaches the MG.

77. On information and belief, during an Outbound Call, the MG similarly receives analog audio from the PSTN and places portions of the digital audio into the payloads of RTP voice packets, as detailed above (*see* ¶¶ 59–64). On information and belief, the MG puts the MTA's IP address, which it received from the MTA, in the destination address field of the RTP vice packets' IP headers. On information and belief, the MG then sends the RTP voice packet to Defendant's IP network, where it reaches the CMTS local to the called party's MTA. On information and belief, the CMTS then sends the RTP voice packet to the MTA over the local coaxial cable network.

COUNT 1: PATENT INFRINGEMENT
Infringement of the ‘084 Patent

78. Sprint realleges and incorporates by reference the allegations set forth in paragraphs 1–77 above.

79. Upon information and belief, Defendants each directly infringed, either individually or jointly, the ‘084 Patent by making, using, selling, and offering for sale broadband and/or packet-based telephony products or services, including the Accused Products and Services, that infringed the ‘084 Patent. These broadband and/or packed-based telephony products and/or services were capable of receiving and did receive telephone calls originating from a non-packet network, such as, for example, the PSTN, in a manner that directly infringed at least claim 1 of the ‘084 Patent under 35 U.S.C. § 271(a).

80. For example, on information and belief, Defendants each (alone or in combination with its subsidiaries, parent, and/or third-party vendors acting under contract) implemented a method of operating an interworking unit to handle a plurality of calls. *See, e.g.*, ¶¶ 55-77, *supra*. On further information and belief, Defendants each received messages into the interworking unit on a call-by-call basis where the messages indicated one of a plurality of synchronous connections and a corresponding one of a plurality of identifiers. *See, e.g.*, ¶ 57, *supra*. On further information and belief, Defendants each received user communications for the calls from the synchronous connections indicated in the messages into the interworking unit. *See, e.g.*, ¶¶ 60-64, *supra*. On further information and belief, Defendants each, in response to the messages, converted the user communications from the synchronous connections into asynchronous communications including the corresponding identifiers. *See, e.g.*, *id*. On further information and belief, Defendants each transferred the asynchronous communications for subsequent routing based on the identifiers. *See, e.g.*, *id*. On further information and belief, each of these steps was performed by or on behalf of

each Defendant.

81. As a direct and proximate consequence of Defendants' infringement of the '084 Patent, Sprint has suffered damages in an amount not yet determined for which Sprint is entitled to relief.

COUNT 2: PATENT INFRINGEMENT
Infringement of the '3,561 Patent

82. Sprint realleges and incorporates by reference the allegations set forth in paragraphs 1–81 above.

83. Upon information and belief, Defendants each directly, either individually or jointly, infringed the '3,561 Patent by making, using, selling, and offering for sale broadband and/or packet-based telephony products or services, including the Accused Products and Services, that infringed the '3,561 Patent. These broadband and/or packet-based telephony products and/or services were capable of placing and did place telephone calls that terminated on a non-packet network, such as, for example, the PSTN, in a manner that directly infringed at least claims 1 and 24 of the '3,561 Patent under 35 U.S.C. § 271(a).

84. For example, on information and belief, Defendants each (alone or in combination with its subsidiaries, parent, and/or third-party vendors acting under contract) implemented a method of operating a processing system to control a packet communication system for a user communication. *See, e.g.*, ¶¶ 55-64, *supra*. On further information and belief, Defendants each received a signaling message for the user communication from a narrowband communication system into the processing system. *See, e.g.*, ¶ 55, *supra*. On further information and belief, Defendants each processed the signaling message to select a network code that identified a network element to provide egress from the packet communication system for the user communication. *See, e.g.*, ¶¶ 55-56. On further information and belief, Defendants each generated a control

message indicating the network code. *See, e.g.*, ¶¶ 57-58, *supra*. On further information and belief, Defendants each transferred the control message from the processing system to the packet communication system. *See, e.g.*, *id*. On further information and belief, Defendants each received the user communication in the packet communication system and used the network code to route the user communication through the packet communication system to the network element. *See, e.g.*, ¶¶ 60-64, *supra*. On further information and belief, Defendants each transferred the user communication from the network element to provide egress from the packet communication system. *See, e.g.*, *id*.

85. Furthermore, on information and belief, Defendants each implemented a method of operating a processing system to control a packet communication system for a user communication. *See, e.g.*, ¶¶ 69-77, *supra*. On further information and belief, Defendants each selected a network code that identified a network element to provide egress for the user communication from the packet communication system to a narrowband communication system. *See, e.g.*, ¶¶ 69-75, *supra*. On further information and belief, Defendants each generated a control message indicating the network code and transferred the control message from the processing system to the packet communication system. *See, e.g.*, ¶ 75, *supra*. On further information and belief, Defendants each generated a signaling message for the user communication and transferred the signaling message from the processing system to the narrowband communication system. *See, e.g.*, ¶¶ 71-75, *supra*. On further information and belief, Defendants each received the user communication in the packet communication system and used the network code to route the user communication through the packet communication system to the network element. *See, e.g.*, ¶¶ 76-77, *supra*. On further information and belief, Defendants each transferred the user communication from the network element to the narrowband communication system to provide egress from the

packet communication system. *See, e.g.*, ¶¶ 76-77, *supra*. On further information and belief, each of these steps was performed by or on behalf of each Defendant.

86. On information and belief, Defendants each has willfully infringed at least claim 1 and 24 of the '3,561 Patent. *See, e.g.*, ¶¶ 50-51, *supra*.

87. As a direct and proximate consequence of Defendants' infringement of the '3,561 Patent, Sprint has suffered damages in an amount not yet determined for which Sprint is entitled to relief.

COUNT 3: PATENT INFRINGEMENT
Infringement of the '052 Patent

88. Sprint realleges and incorporates by reference the allegations set forth in paragraphs 1–87 above.

89. Upon information and belief, Defendants each directly, either individually or jointly, infringed the '052 Patent by making, using, selling, and offering for sale broadband and/or packet-based telephony products or services, including the Accused Products and Services, and other related telephony services, that infringed the '052 Patent. These broadband and/or packet-based telephony products and/or services were capable of receiving and did receive telephone calls originating from a non-packet network, such as, for example, the PSTN, in a manner that directly infringed at least claim 1 of the '052 Patent under 35 U.S.C. § 271(a).

90. For example, on information and belief, Defendants each (alone or in combination with its subsidiaries, parent, and/or third-party vendors acting under contract) implemented a method of transferring a user communication to a packet communication system. *See, e.g.*, ¶¶ 55-64, *supra*. On further information and belief, Defendants each received the user communication into a device. *See, e.g.*, ¶¶ 60-64, *supra*. On further information and belief, Defendants each received signaling formatted for a narrowband system into a processing system. *See, e.g.*, ¶¶ 55-

56, *supra*. On further information and belief, Defendants each processed, in the processing system, the signaling to select a network code that identified a network element to provide egress for the user communication from the packet communication system. *See, e.g.*, *id*. On further information and belief, Defendants each transferred an instruction indicating the network code from the processing system to the device. *See, e.g.*, ¶¶ 57-58, *supra*. On further information and belief, Defendants each transferred a packet including the network code and the user communication from the device to the packet communication system in response to the instruction. *See, e.g.*, ¶¶ 60-64, *supra*. On further information and belief, each of these steps was performed by or on behalf of each Defendant.

91. On information and belief, Defendants each has willfully infringed at least claim 1 of the ‘052 Patent. *See, e.g.*, ¶¶ 50-51, *supra*.

92. As a direct and proximate consequence of Defendants’ infringement of the ‘052 Patent, Sprint has suffered damages in an amount not yet determined for which Sprint is entitled to relief.

COUNT 4: PATENT INFRINGEMENT
Infringement of the ‘932 Patent

93. Sprint realleges and incorporates by reference the allegations set forth in paragraphs 1–92 above.

94. Upon information and belief, Defendants each directly, either individually or jointly, infringed the ‘932 Patent by making, using, selling, and offering for sale broadband and/or packet-based telephony products or services, including the Accused Products and Services, and other related telephony services, that infringed the ‘932 Patent. These broadband and/or packet-based telephony products and/or services were capable of placing and did place telephone calls

that terminated on a non-packet network, such as, for example, the PSTN, in a manner that directly infringed at least claim 1 of the '932 Patent under 35 U.S.C. § 271(a).

95. For example, on information and belief, Defendants each (alone or in combination with its subsidiaries, parent, and/or third-party vendors acting under contract) implemented a method of handling a call having a first message and communications. *See, e.g.*, ¶¶ 69-77, *supra*. On further information and belief, Defendants each operated a processing system external to narrowband switches that received and processed the first message to select one of the narrowband switches. *See, e.g.*, ¶¶ 69-73, *supra*. On further information and belief, Defendants each generated a second message in the processing system based on the selected narrowband switch and transmitted the message from the processing system. *See, e.g.*, ¶¶ 69-75, *supra*. On further information and belief, Defendants each received the second message and communications and transferred the communications to the narrowband switch in response to the second message. *See, e.g.*, ¶¶ 76-77, *supra*. On further information and belief, each of these steps was performed by or on behalf of each Defendant.

96. On information and belief, Defendants each has willfully infringed at least claim 1 of the '932 Patent. *See, e.g.*, ¶¶ 50-5151, *supra*.

97. As a direct and proximate consequence of Defendants' infringement of the '932 Patent, Sprint has suffered damages in an amount not yet determined for which Sprint is entitled to relief.

COUNT 5: PATENT INFRINGEMENT
Infringement of the '429 Patent

98. Sprint realleges and incorporates by reference the allegations set forth in paragraphs 1–97 above.

99. Upon information and belief, Defendants each directly, either individually or jointly, infringed the ‘429 Patent by making, using, selling, and offering for sale broadband and/or packet-based telephony products or services, including the Accused Products and Services, and other related telephony services, that infringed the ‘429 Patent. These broadband and/or packet-based telephony products and/or services were capable of receiving and did receive telephone calls originating from a non-packet network, such as, for example, the PSTN, in a manner that directly infringed at least claim 1 of the ‘429 Patent under 35 U.S.C. § 271(a).

100. For example, on information and belief, Defendants each (alone or in combination with its subsidiaries, parent, and/or third-party vendors acting under contract) implemented a communication method for transferring telecommunication signals for a call. *See, e.g.*, ¶¶ 55-64, *supra*. On further information and belief, Defendants each received information associated with a user communication into a processing system. *See, e.g.*, ¶¶ 55-56, *supra*. On further information and belief, Defendants each processed the information in the processing system to select an identifier. *See, e.g.*, *id*. On further information and belief, Defendants each generated a message containing the identifier. *See, e.g.*, ¶ 56-58, *supra*. On further information and belief, Defendants each transmitted the message from the processing system. *See, e.g.*, *id*. On further information and belief, Defendants each received the message into an interworking unit. *See, e.g.*, *id*. On further information and belief, Defendants each received the user communication into the interworking unit from a DS0 connection. *See, e.g.*, ¶¶ 60-62, *supra*. On further information and belief, Defendants each, in the interworking unit, converted the user communication into an asynchronous communication with the identifier in a header in response to the message. *See, e.g.*, *id*. On further information and belief, Defendants each transferred the asynchronous communication from the interworking unit. *See, e.g.*, *id*. On further information and belief, each of these steps was

performed by or on behalf of each Defendant.

101. On information and belief, Defendants each has willfully infringed at least claim 1 of the '429 Patent. *See, e.g.*, ¶¶ 50-51, *supra*.

102. As a direct and proximate consequence of Defendants' infringement of the '429 Patent, Sprint has suffered damages in an amount not yet determined for which Sprint is entitled to relief.

COUNT 6: PATENT INFRINGEMENT
Infringement of the '064 Patent

103. Sprint realleges and incorporates by reference the allegations set forth in paragraphs 1-102 above.

104. Upon information and belief, Defendants each directly, either individually or jointly, infringed the '064 Patent by making, using, selling, and offering for sale broadband and/or packet-based telephony products or services, including the Accused Products and Services, and other related telephony services, that infringed the '064 Patent. These broadband and/or packet-based telephony products and/or services were capable of placing and did place telephone calls that terminate on a non-packet network, such as, for example, the PSTN, in a manner that directly infringed at least claim 1 of the '064 Patent under 35 U.S.C. § 271(a).

105. For example, on information and belief, Defendants each (alone or in combination with its subsidiaries, parent, and/or third-party vendors acting under contract) implemented a method for a call. *See, e.g.*, ¶¶ 69-77, *supra*. On further information and belief, Defendants each received set-up signaling associated with the call into a processing system. *See, e.g.*, ¶ 69, *supra*. On further information and belief, Defendants each processed the set-up signaling in the processing system to select a DS0 connection. *See, e.g.*, ¶¶ 69-73. On further information and belief, Defendants each generated a message identifying the DS0 connection. *See, e.g.*, *id*. On

further information and belief, Defendants each transmitted the message from the processing system. *See, e.g.*, ¶¶ 72-75, *supra*. On further information and belief, Defendants each received the message and an asynchronous communication associated with the call into an interworking unit. *See, e.g.*, ¶¶ 76-77. On further information and belief, Defendants each, in the interworking unit, converted the asynchronous communication into a user communication. *See, e.g.*, *id*. On further information and belief, Defendants each transferred the user communication from the interworking unit to the DS0 connection in response to the message. *See, e.g.*, *id*. On further information and belief, each of these steps was performed by or on behalf of each Defendant.

106. On information and belief, Defendants each has willfully infringe at least claim 1 of the '064 Patent. *See, e.g.*, ¶¶ 50-51, *supra*.

107. As a direct and proximate consequence of Defendants' infringement of the '064 Patent, Sprint has suffered damages in an amount not yet determined for which Sprint is entitled to relief.

COUNT 7: PATENT INFRINGEMENT
Infringement of the '224 Patent

108. Sprint realleges and incorporates by reference the allegations set forth in paragraphs 1–107 above.

109. Upon information and belief, Defendants each directly, either individually or jointly, infringed the '224 Patent by making, using, selling, and offering for sale broadband and/or packet-based telephony products or services, including the Accused Products and Services, and other related telephony services, that infringed the '224 Patent. These broadband and/or packet-based telephony products and/or services were capable of providing and did provide enhanced services in a manner that directly infringed at least claim 1 of the '224 Patent under 35 U.S.C. § 271(a).

110. For example, on information and belief, Defendants each (alone or in combination with its subsidiaries, parent, and/or third-party vendors acting under contract) implemented a method for operating a communication system. *See, e.g.*, ¶¶ 55-68 , *supra*. On further information and belief, Defendants each received information into a processing system wherein the information is related to a user communication in a first communication format. *See, e.g.*, ¶¶ 55-56, 65, *supra*. On further information and belief, Defendants each, in the processing system, selected a service and a service node to provide the service based on the information. *See, e.g.*, ¶¶ 65-68. On further information and belief, Defendants each, in the processing system, generated and transmitted a first message from the processing system. *See, e.g.*, *id*. On further information and belief, Defendants each, in the processing system, generated and transmitted a second message from the processing system to the service node wherein the second message indicated the selected service and a user. *See, e.g.*, *id*. On further information and belief, Defendants each received the user communication in the first communication format and the first message into an interworking unit. *See, e.g.*, *id*. On further information and belief, Defendants each, in the interworking unit, converted the user communication from the first communication format to a second communication format and transmitted the user communication in the second communication format to the service node in response to the first message. *See, e.g.*, *id*. On further information and belief, each of these steps was performed by or on behalf of each Defendant.

111. As a direct and proximate consequence of Defendants' infringement of the '224 Patent, Sprint has suffered damages in an amount not yet determined for which Sprint is entitled to relief.

COUNT 8: PATENT INFRINGEMENT
Infringement of the ‘340 Patent

112. Sprint realleges and incorporates by reference the allegations set forth in paragraphs 1–111 above.

113. Upon information and belief, Defendants each directly, either individually or jointly, infringed the ‘340 Patent by making, using, selling, and offering for sale broadband and/or packet-based telephony products or services, including the Accused Products and Services, and other related telephony services, that infringed the ‘340 Patent. These broadband and/or packet-based telephony products and/or services were capable of providing and did provide enhanced services in a manner that directly infringed at least claim 11 of the ‘340 Patent under 35 U.S.C. § 271(a).

114. For example, on information and belief, Defendants each (alone or in combination with its subsidiaries, parent, and/or third-party vendors acting under contract) implemented a method of operating a communication system. *See, e.g.*, ¶¶ 55-68 , *supra*. On further information and belief, Defendants each, in a signaling processor, received and processed Signaling System Seven (SS7) signaling for a call, and in response, generated and transferred control messaging indicating identifiers that are used for routing. *See, e.g.*, ¶¶ 55-56, 65. On further information and belief, Defendants each, in a service platform system, received the control messaging, and in response, exchanged communications that included the identifiers to interact with a caller to provide a service. *See, e.g.*, ¶¶ 65-68. On further information and belief, each of these steps was performed by or on behalf of each Defendant.

115. As a direct and proximate consequence of Defendants’ infringement of the ‘340 Patent, Sprint has suffered damages in an amount not yet determined for which Sprint is entitled to relief.

COUNT 9: PATENT INFRINGEMENT
Infringement of the '6,561 Patent

116. Sprint realleges and incorporates by reference the allegations set forth in paragraphs 1–115 above.

117. Upon information and belief, Defendants each directly, either individually or jointly, infringed the '6,561 Patent by making, using, selling, and offering for sale broadband and/or packet-based telephony products or services, including the Accused Products and Services, and other related telephony services, that infringed the '6,561 Patent. These broadband and/or packet-based telephony products and/or services were capable of receiving and did receive telephone calls originating from a non-packet network, such as, for example, the PSTN, in a manner that directly infringed at least claim 11 of the '6,561 Patent under 35 U.S.C. § 271(a).

118. For example, on information and belief, Defendants each (alone or in combination with its subsidiaries, parent, and/or third-party vendors acting under contract) implemented a method of operating a communication system. *See, e.g.*, ¶¶ 55-64, *supra*. On further information and belief, Defendants each, in a processing system, processed one of a Signaling System #7 (SS7) signaling message and a Q.931 signaling message for a call to select packet routing information for the call and transferred a control message indicating packet routing information. *See, e.g.*, ¶¶ 55-64, *supra*. On further information and belief, Defendants each, in a communication system, received a user communication for the call and the control message, and in response, converted the user communication into a packet format including the packet routing information selected by the processing system and transferred the user communication in the packet format to a packet system that routed the user the packet routing information selected by the processing system. *See, e.g.*, ¶¶ 55-64, *supra*. On further information and belief, each of these steps was performed by or on behalf of each Defendant.

119. As a direct and proximate consequence of Defendants' infringement of the '6,561 Patent, Sprint has suffered damages in an amount not yet determined for which Sprint is entitled to relief.

COUNT 10: PATENT INFRINGEMENT
Infringement of the '454 Patent

120. Sprint realleges and incorporates by reference the allegations set forth in paragraphs 1–119 above.

121. Upon information and belief, Defendants each directly, either individually or jointly, infringed the '454 Patent by making, using, selling, and offering for sale broadband and/or packet-based telephony products or services, including the Accused Products and Services, and other related telephony services, that infringed the '454 Patent. These broadband and/or packet-based telephony products and/or services were capable of placing and did place telephone calls that terminated on a non-packet network, such as, for example, the PSTN, in a manner that directly infringed at least claim 1 of the '454 Patent under 35 U.S.C. § 271(a).

122. For example, on information and belief, Defendants each (alone or in combination with its subsidiaries, parent, and/or third-party vendors acting under contract) implemented a method of operating a telecommunication system. *See, e.g.*, ¶¶ 69-77, *supra*. On further information and belief, Defendants each received a first signaling from customer premises equipment into a communication control processor. *See, e.g.*, ¶¶ 69-70, *supra*. On further information and belief, Defendants each processed the first signaling in the communication control processor to select an address of a network element. *See, e.g.*, ¶¶ 69-71. On further information and belief, Defendants each transferred second signaling indicating the address from the communication control processor. *See, e.g.*, ¶¶ 75-76, *supra*. On further information and belief, Defendants each transferred third signaling from the communication control processor to a

narrowband network. *See, e.g.*, ¶¶ 75-76, *supra*. On further information and belief, Defendants each received a voice communication from the customer premises equipment into a broadband network. *See, e.g.*, ¶ 76, *supra*. On further information and belief, Defendants each transferred the voice communication in the broadband network to the network element. *See, e.g.*, *id*. On further information and belief, Defendants each transferred the voice communication from the network element to the narrowband network. *See, e.g.*, *id*. On further information and belief, each of these steps was performed by or on behalf of each Defendant.

123. As a direct and proximate consequence of Defendants' infringement of the '454 Patent, Sprint has suffered damages in an amount not yet determined for which Sprint is entitled to relief.

COUNT 11: PATENT INFRINGEMENT
Infringement of the '728 Patent

124. Sprint realleges and incorporates by reference the allegations set forth in paragraphs 1–123 above.

125. Upon information and belief, Defendants each directly, either individually or jointly, infringed the '728 Patent by making, using, selling, and offering for sale broadband and/or packet-based telephony products or services, including the Accused Products and Services, and other related telephony services, that infringed the '728 Patent. These broadband and/or packet-based telephony products and/or services were capable of receiving and did receive telephone calls originating from a non-packet network, such as, for example, the PSTN, in a manner that directly infringed at least claim 1 of the '728 Patent under 35 U.S.C. § 271(a).

126. For example, on information and belief, Defendants each (alone or in combination with its subsidiaries, parent, and/or third-party vendors acting under contract) implemented a method of operating a communication system. *See, e.g.*, ¶¶ 55-64, *supra*. On further information

and belief, Defendants each received telecommunication signaling for calls into a signaling processor, and responsively on a call-by-call basis, selected routing information based on the telecommunication signaling and transferred control messages indicating the routing information. *See, e.g.*, ¶¶ 55-57, *supra*. On further information and belief, Defendants each received the control messages and user communications for the calls into a communication unit, and responsively on the call-by-call basis, converted the user communications from a first communication format into a second communication format having headers that included the routing information selected by the signaling processor and transferred the user communications in the second communication format. *See, e.g.*, ¶¶ 57-64, *supra*. On further information and belief, each of these steps was performed by or on behalf of each Defendant.

127. As a direct and proximate consequence of Defendants' infringement of the '728 Patent, Sprint has suffered damages in an amount not yet determined for which Sprint is entitled to relief.

COUNT 12: PATENT INFRINGEMENT
Infringement of the '534 Patent

128. Sprint realleges and incorporates by reference the allegations set forth in paragraphs 1–127 above.

129. Upon information and belief, Defendants each directly, either individually or jointly, infringed the '534 Patent by making, using, selling, and offering for sale broadband and/or packet-based telephony products or services, including the Accused Products and Services, and other related telephony services, that infringed the '534 Patent. These broadband and/or packet-based telephony products and/or services were capable of placing and did place telephone calls that terminated on a non-packet network, such as, for example, the PSTN, in a manner that directly infringed at least claim 1 of the '534 Patent under 35 U.S.C. § 271(a).

130. For example, on information and belief, Defendants each (alone or in combination with its subsidiaries, parent, and/or third-party vendors acting under contract) implemented a method of operating a communication system. *See, e.g.*, ¶¶ 69-77, *supra*. On further information and belief, Defendants each transferred a dial tone from a bearer interface for a caller. *See, e.g.*, ¶ 69, *supra*. On further information and belief, Defendants each received Dual Tone Multi-Frequency (DTMF) signals from the caller into the bearer interface. *See, e.g.*, ¶¶ 69-70. On further information and belief, Defendants each processed the DTMF signals in the bearer interface to determine a called number. *See, e.g.*, ¶¶ 69-70. On further information and belief, Defendants each transferred a first message indicating the called number from the bearer interface to a processing system. *See, e.g.*, *id*. On further information and belief, Defendants each processed the called number in the processing system to select an identifier. *See, e.g.*, ¶¶ 70-75, *supra*. On further information and belief, Defendants each transferred a second message indicating the identifier from the processing system to the bearer interface. *See, e.g.*, *id*. On further information and belief, Defendants each received the user communications into the bearer interface, and in response to the second message, converted the user communications into a packet format including the identifier and transferred the user communications in the packet format including the identifier to a communication network, wherein the communication network routed the user communications based on the identifier. *See, e.g.*, ¶¶ 76-77, *supra*. On further information and belief, each of these steps was performed by or on behalf of each Defendant.

131. As a direct and proximate consequence of Defendants' infringement of the '534 Patent, Sprint has suffered damages in an amount not yet determined for which Sprint is entitled to relief.

COUNT 13: PATENT INFRINGEMENT
Infringement of the '131 Patent

132. Sprint realleges and incorporates by reference the allegations set forth in paragraphs 1–131 above.

133. Upon information and belief, Defendants each has been, and/or currently is, directly infringing, either individually or jointly, the '131 Patent by making, using, selling, and offering for sale broadband and/or packet-based telephony products or services, including the Accused Products and Services, and other related telephony services, that infringe the '131 Patent. These broadband and/or packet-based telephony products and/or services are capable of placing and do place telephone calls that terminate on a non-packet network, such as, for example, the PSTN, in a manner that directly infringes at least claim 11 of the '131 Patent under 35 U.S.C. § 271(a).

134. For example, on information and belief, Defendants each (alone or in combination with its subsidiaries, parent, and/or third-party vendors acting under contract) implements a method of operating a communication system to provide Public Switched Telephone Network (PSTN) access to a residential communication hub. *See, e.g.*, ¶¶ 69-77, *supra*. On further information and belief, Defendants each, in the residential communication hub that is coupled to a packet network over a packet connection, exchanges telephony control signaling and telephony user communications in a PSTN format with an analog telephone, converts the telephony control signaling and the telephony user communications in the PSTN format to a packet format, exchanges the telephony control signaling in the packet format with a service node over the packet connection, wherein the service node comprises a call manager and a voice mux, exchanges the telephony user communications in the packet format with the service node over the packet connection, and exchanges Internet communications with the service node over the packet connection. *See, e.g.*, ¶¶ 69-77. On further information and belief, Defendants each, in the call manager that is coupled to the packet network, processes the telephony control signaling to select

a PSTN connection of the PSTN, transfers a control message indicating the selected PSTN connection, converts the telephony control signaling between the packet format and the PSTN format, and exchanges the telephony control signaling in the PSTN format with the PSTN over a signaling interface of the PSTN. *See, e.g.*, *id*. On further information and belief, Defendants each, in the voice mux that is coupled to the packet network, receives the control message from the call manager, and in response, exchanges the telephony user communications in the packet format with the residential communication hub, converts the telephony user communications between the packet format and the PSTN format, and exchanges the telephony user communications in the PSTN format over the selected PSTN connection. *See, e.g.*, *id*. On further information and belief, each of these steps was, and continue to be, performed by or on behalf of each Defendant.

135. As a direct and proximate consequence of Defendants' infringement of the '131 Patent, Sprint has suffered damages in an amount not yet determined for which Sprint is entitled to relief.

COUNT 14: PATENT INFRINGEMENT
Infringement of the '918 Patent

136. Sprint realleges and incorporates by reference the allegations set forth in paragraphs 1–135 above.

137. Upon information and belief, Defendants each has been, and/or currently is, directly infringing, either individually or jointly, the '918 Patent by making, using, selling, and offering for sale broadband and/or packet-based telephony products or services, including the Accused Products and Services, and other related telephony services, that infringe the '918 Patent. These broadband and/or packet-based telephony products and/or services are capable of placing and do place telephone calls that terminate on a non-packet network, such as, for example, the PSTN, in a manner that directly infringes at least claim 11 of the '918 Patent under 35 U.S.C. § 271(a).

138. For example, on information and belief, Defendants each (alone or in combination with its subsidiaries, parent, and/or third-party vendors acting under contract) implements a method of operating a communication system. *See, e.g.*, ¶¶ 55-77, *supra*. On further information and belief, each Defendant's control system, which includes control system data tables, receives and processes call routing data to fill the control data tables with the call routing data and also transfers the call routing data from the control system data tables to call processor data tables. *See, e.g.*, ¶¶ 55-56, *supra*. On further information and belief, Defendants each, in a call processor including the call processor data tables, processes signaling information for a call based on the call routing data in the call processor data tables to transfer a control message for the call indicating a first connection and a second connection *See, e.g.*, *id*. On further information and belief, Defendants each, in an interworking unit, receives the control message, and in response to the control message, receives user communications in a first format from a first connection, converts the user communications to a second format, and transfers the user communications in the second format over the second connection. *See, e.g.*, ¶¶ 60-64, 76-77, *supra*. On further information and belief, each of these steps was, and continues to be, performed by or on behalf of each Defendant.

139. As a direct and proximate consequence of Defendants' infringement of the '918 Patent, Sprint has suffered damages in an amount not yet determined for which Sprint is entitled to relief.

COUNT 15: PATENT INFRINGEMENT
Infringement of the '463 Patent

140. Sprint realleges and incorporates by reference the allegations set forth in paragraphs 1–139 above.

141. Upon information and belief, Defendants each has been, and/or currently is, directly infringing, either individually or jointly, the '463 Patent by making, using, selling, and offering for

sale broadband and/or packet-based telephony products or services, including the Accused Products and Services, and other related telephony services, that infringe the ‘463 Patent. These broadband and/or packet-based telephony products and/or services are capable of placing and do place telephone calls that terminate on a non-packet network, such as, for example, the PSTN, through LNP querying in a manner that directly infringes at least claim 1 of the ‘463 Patent under 35 U.S.C. § 271(a).

142. For example, on information and belief, Defendants each (alone or in combination with its subsidiaries, parent, and/or third-party vendors acting under contract) implements a method of operating a call signaling processor for a call having a signaling message and a user communication. *See, e.g.*, ¶¶ 69-77, *supra*. On further information and belief, Defendants each received the signaling message for the call indicating a called number. *See, e.g.*, ¶¶ 69–71, *supra*. On information and belief, Defendants each processed the called number to transfer a number portability query. *See, e.g.*, ¶ 71, *supra*. On further information and belief, Defendants each received a number portability response indicating a route number. *See, e.g.*, ¶ 71, *supra*. On further information and belief, Defendants each processed the route number to select an identifier for routing the user communication. *See, e.g.*, ¶¶ 71–77, *supra*. On further information and belief, Defendants each transferred a control message indicating the user communication and the identifier to a communication system, wherein the communication system, in response to the control message, added the identifier to a header of the user communication and routed the user communication based on the identifier in the header. *See, e.g.*, ¶¶ 71–77, *supra*. On further information and belief, each of these steps was performed by or on behalf of each Defendant.

143. As a direct and proximate consequence of Defendants' infringement of the '463 Patent, Sprint has suffered damages in an amount not yet determined for which Sprint is entitled to relief.

PRAYER FOR RELIEF

Wherefore, Sprint requests entry of judgment in its favor and against each Defendant as follows:

A. Judgment that each Defendant has directly infringed one or more claims of Sprint's Patents;

B. An award of damages to compensate Sprint for each Defendant infringement, including damages pursuant to 35 U.S.C. § 284, as well as prejudgment and post-judgment interest;

C. An award of costs and expenses in this action, including an award of Sprint's reasonable attorneys' fees pursuant to 35 U.S.C. § 285;

D. A permanent injunction restraining and enjoining each Defendant, and its respective officers, agents, servants, employees, attorneys, and those persons in active concert or participation with each Defendant who receive actual notice of the order by personal service or otherwise, from any further sales or use of their infringing products and/or services and any other infringement of the '131 Patent;

E. A finding that each Defendant has willfully infringed and is willfully infringing one or more claims of one or more of the Asserted Patents;

F. A finding that this is an exceptional case, award treble damages due to deliberate and willful conduct by each Defendant, and order Defendants each to pay Sprint's costs of suit and attorneys' fees; and

G. For such other and further relief as the Court may deem just, proper, and equitable under the circumstances.

DEMAND FOR JURY TRIAL

Sprint respectfully demands a trial by jury on all claims and issues so triable.

Respectfully submitted,

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Dated: June 28, 2019

EXHIBIT A

US006343084B1

(12) **United States Patent**
Christie

(10) **Patent No.: US 6,343,084 B1**
(45) **Date of Patent: *Jan. 29, 2002**

(54) **BROADBAND TELECOMMUNICATIONS SYSTEM**

(75) Inventor: **Joseph Michael Christie**, San Bruno, CA (US)

(73) Assignee: **Sprint Communications Company, L.P.**, Kansas City, MO (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **09/439,033**

(22) Filed: **Nov. 12, 1999**

Related U.S. Application Data

(63) Continuation-in-part of application No. 08/568,551, filed on Dec. 7, 1995, now Pat. No. 5,825,780, which is a continuation of application No. 08/525,897, filed on Sep. 8, 1995, now Pat. No. 5,991,301, which is a continuation of application No. 08/238,605, filed on May 5, 1994, now abandoned.

(51) **Int. Cl.**[7] **H04J 3/16**; H04J 3/22

(52) **U.S. Cl.** **370/466**

(58) **Field of Search** 370/395, 389, 370/396, 397, 398, 399, 400, 466, 422, 465; 379/224, 230

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,453,247	A	6/1984	Suzuki et al.
4,720,850	A	1/1988	Oberlander et al.
4,763,317	A	8/1988	Lehman et al.
4,926,416	A	5/1990	Weik
5,051,983	A	9/1991	Kammerl
5,115,431	A	5/1992	Williams et al.
5,168,492	A	12/1992	Beshai et al.

(List continued on next page.)

OTHER PUBLICATIONS

David Giddy, "An Experimental ATM Network Featuring De–Coupled Modular Control," Telecom Australia Research Laboratories, Victoria, Australia, IEEE 1992, pp. 118–122.

Shin–Ichi Kuribayashi, "Advanced Signaling Protocol for Braodband ISDN Services," NTT Communication Switching Laboratories, Musashino, Japan, Electronics and Communications in Japan, Part 1, vol. 78, No. 1, 1995, pp. 1–12.

R. Scott McKinney, "ATM for Narrowband Services" IEEE Communictions Magazine 1994 Apr. No. 4, New York, pp. 64–72.

Shirou Tanabe, "A New Distributed Switching System Architecture for B–ISDN,"The Electronics Division of the Institution of Electrical Engineers, 1990, Savoy Place, London, pp. 259–263.

ITU–T "Line Transmission of Non–Telephone Signals, Framework for Recommendations for Audiovisual Services," H.200 1993, pp. 1–4.

CCITT, I.1121, "Integrated Services Digital Netowrk (ISDN) General Structure and Service Capabilities, Broadband Aspects of ISDN,"1991, pp. 1–2.

ITU–T, Q. 1218 Addendum 1, "Series Q: Switching and Signalling Intelligent Network Interface Recommendation for Intelligent Network CS–1 Addendum 1: Definition for two new contexts in the SDF data model,"1998.

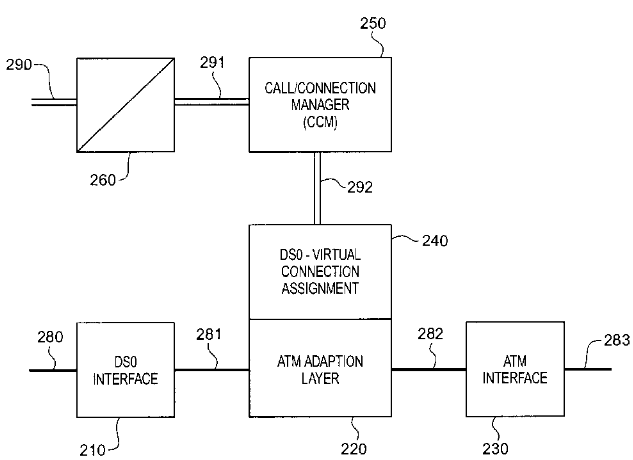
(List continued on next page.)

Primary Examiner—Ajit Patel
(74) *Attorney, Agent, or Firm*—Harley R. Ball

(57) **ABSTRACT**

The invention is a system for providing virtual connections through an ATM interworking multiplexer on a call-by-call basis. A signaling processor receives signaling for a call and selects the virtual connection for the call. The signaling processor generates new signaling that identifies the selection and transfers the new signaling to the ATM interworking multiplexer that accepted the access connection for the call. The multiplexer converts user information from the access connection into ATM cells for transmission over the virtual connection in accord with the new signaling.

16 Claims, 12 Drawing Sheets



U.S. PATENT DOCUMENTS

5,204,857 A		4/1993	Obara	
5,233,607 A		8/1993	Barwig et al.	
5,274,680 A		12/1993	Sorton et al.	
5,327,421 A		7/1994	Hiller et al.	
5,339,318 A		8/1994	Tanaka et al.	
5,345,445 A		9/1994	Hiller et al.	
5,345,446 A		9/1994	Hiller et al.	
5,365,524 A		11/1994	Hiller et al.	
5,392,402 A		2/1995	Robrock, II	
5,414,701 A		5/1995	Shtayer et al.	
5,420,858 A		5/1995	Marshall et al.	
5,422,882 A		6/1995	Hiller et al.	
5,426,636 A		6/1995	Hiller et al.	
5,428,607 A		6/1995	Hiller et al.	
5,428,609 A		6/1995	Eng, et al.	
5,434,852 A		7/1995	La Porta et al.	
5,452,296 A		9/1995	Shimizu	
5,452,297 A		9/1995	Hiller et al.	
5,459,722 A		10/1995	Sherif	
5,473,679 A		12/1995	La Porta et al.	
5,479,402 A		12/1995	Hata et al.	
5,483,527 A	*	1/1996	Doshi et al.	379/220
5,509,010 A		4/1996	LaPorta et al.	
5,530,724 A		6/1996	Abrams et al.	
5,568,475 A	*	10/1996	Doshi et al.	379/220
5,570,368 A		10/1996	Murakami et al.	
5,577,039 A		11/1996	Won et al.	
5,600,643 A	*	2/1997	Robrock, II	370/399
5,623,491 A		4/1997	Skoog	
5,623,493 A		4/1997	Kagemoto	
5,673,262 A		9/1997	Shimizu	
5,684,792 A		11/1997	Ishihara	
5,771,231 A	*	6/1998	Watanabe	370/337
5,771,234 A		6/1998	Wu et al.	
5,787,086 A		7/1998	McClure et al.	
5,805,568 A		9/1998	Shinbashi	
5,825,780 A		10/1998	Christie	
5,926,482 A		7/1999	Christie et al.	
5,991,301 A		11/1999	Christie	
6,014,378 A		1/2000	Christie et al.	
6,016,319 A		1/2000	Kshirsagar et al.	
6,016,343 A		1/2000	Hogan et al.	
6,023,474 A		2/2000	Gardner et al.	
6,064,648 A		5/2000	Hellman et al.	
6,067,299 A		5/2000	DuRee	
6,081,529 A		6/2000	Christie	

OTHER PUBLICATIONS

ITU–T Q. 1208, "General Recommendations on Telephone Switching and Signalling Network General Aspects of the Intelligent Network Application Protocol," 1993.

McDysan, David E. And Spohn, Darren L., ATM Theory And Application, 1994, p. 256: 9.3.1; ATM Layer VPI/VCI Level Addressing.

"Revised Draft Of Q.2650 (DSS2/B–ISUP Interworking Recommendation)," Study Gruop 11, GEneva, ITU—Telecommunication Standardization Sector, Nov. 29–Dec. 17, 1993.

"Draft Broadband/Narrowband NNI Interworking Recommendation," Study Group 11, Geneva, ITU—Telecommunication Standardization Sector, Dec. 1993.

Yoshikai, N., et al., "General Arrangements for Interworking Between B–ISDN and 64kbit/s Based ISDN (Draft Recommendation 1.580), Study Group 13,"ITU–T Telecommunication Standardization Sector, pp. 1–51, (Mar. 7, 1994).

"Interworking B–ISUP and Q.93B for DDI, TP and SUB", Study Group 11, Temporary Document 2/II–131I, ITU–Telecommunication Standardization Sector, Nov. 29–Dec. 17, 1993.

Minoli, Daniel/DVI Communications, Inc./Stevens Institute of Technology and Dobrowski, George.Bell Communications Research (Bellcore), Priniciples Of Signalling For Cell Relay And Frame Relay © pp. 1–2, 5–6 and 229, 1994.

* cited by examiner

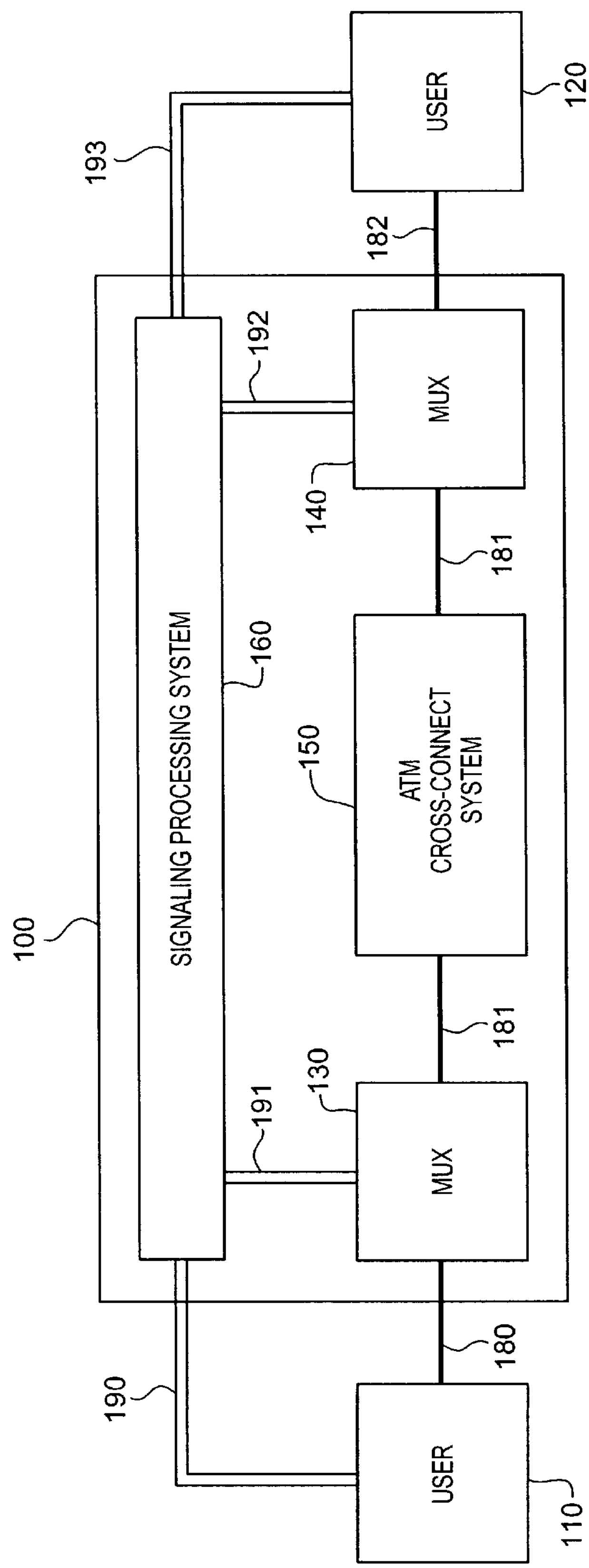

USER
120
193
182
MUX
192
140
181
SIGNALING PROCESSING SYSTEM
160
150
ATM
CROSS-CONNECT
SYSTEM
100
181
130
191
MUX
180
190
USER
110

FIG. 1

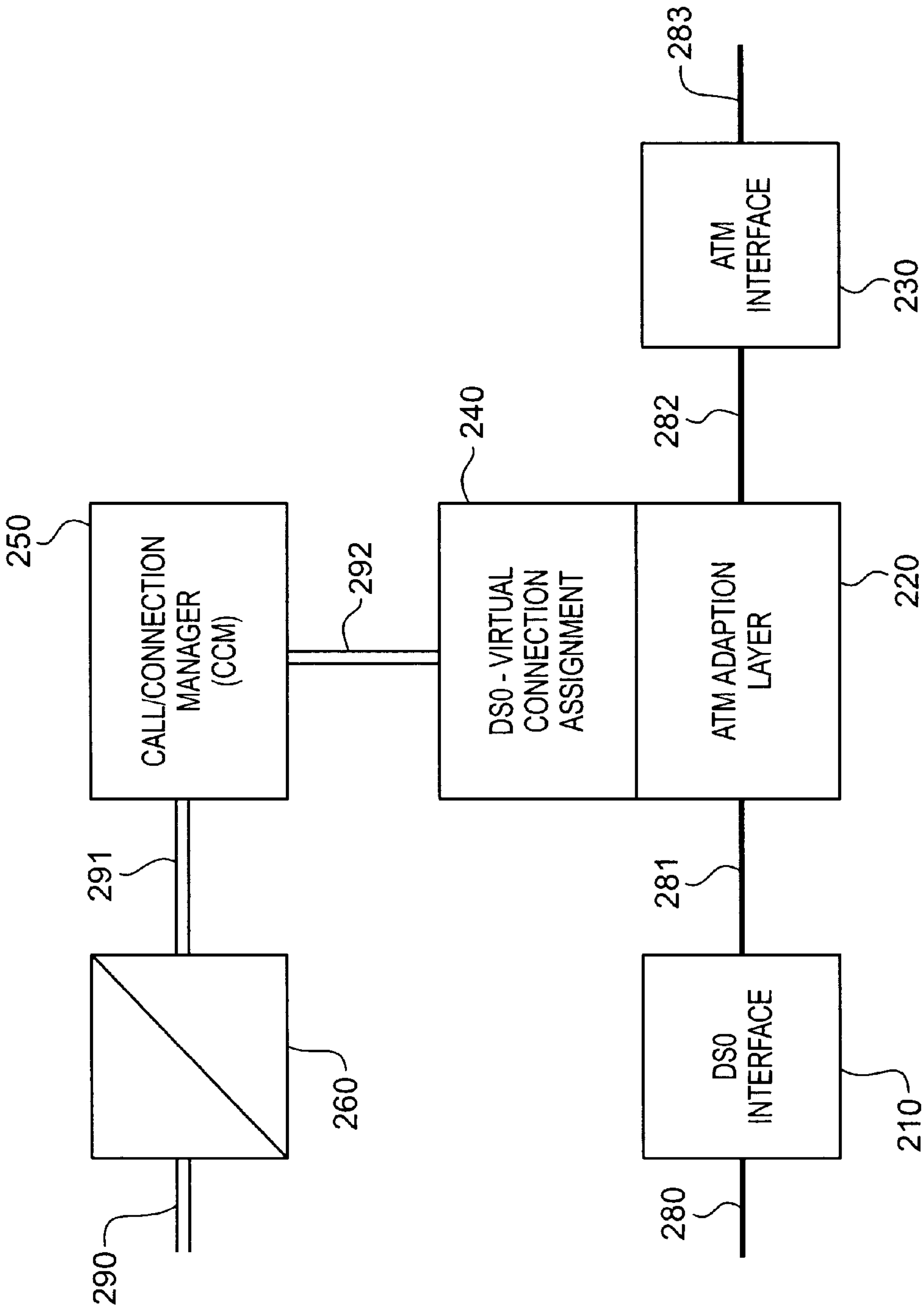

283
ATM INTERFACE
230
282
240
250
CALL/CONNECTION MANAGER (CCM)
292
DS0 - VIRTUAL CONNECTION ASSIGNMENT
ATM ADAPTION LAYER
220
291
281
260
DS0 INTERFACE
210
290
280

FIG. 2

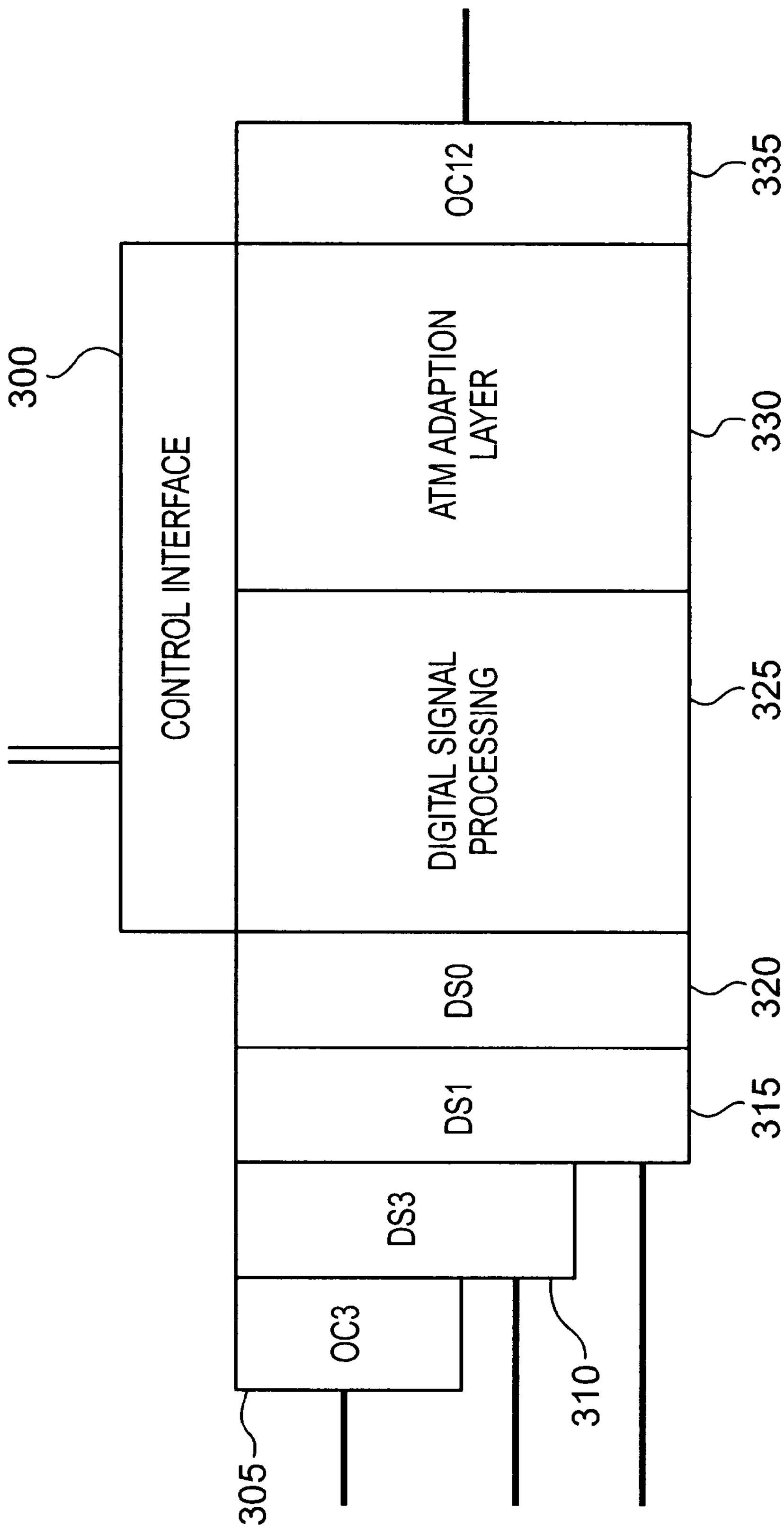

300
CONTROL INTERFACE
OC12
ATM ADAPTION LAYER
DIGITAL SIGNAL PROCESSING
DS0
DS1
DS3
OC3
335
330
325
320
315
310
305

FIG. 3

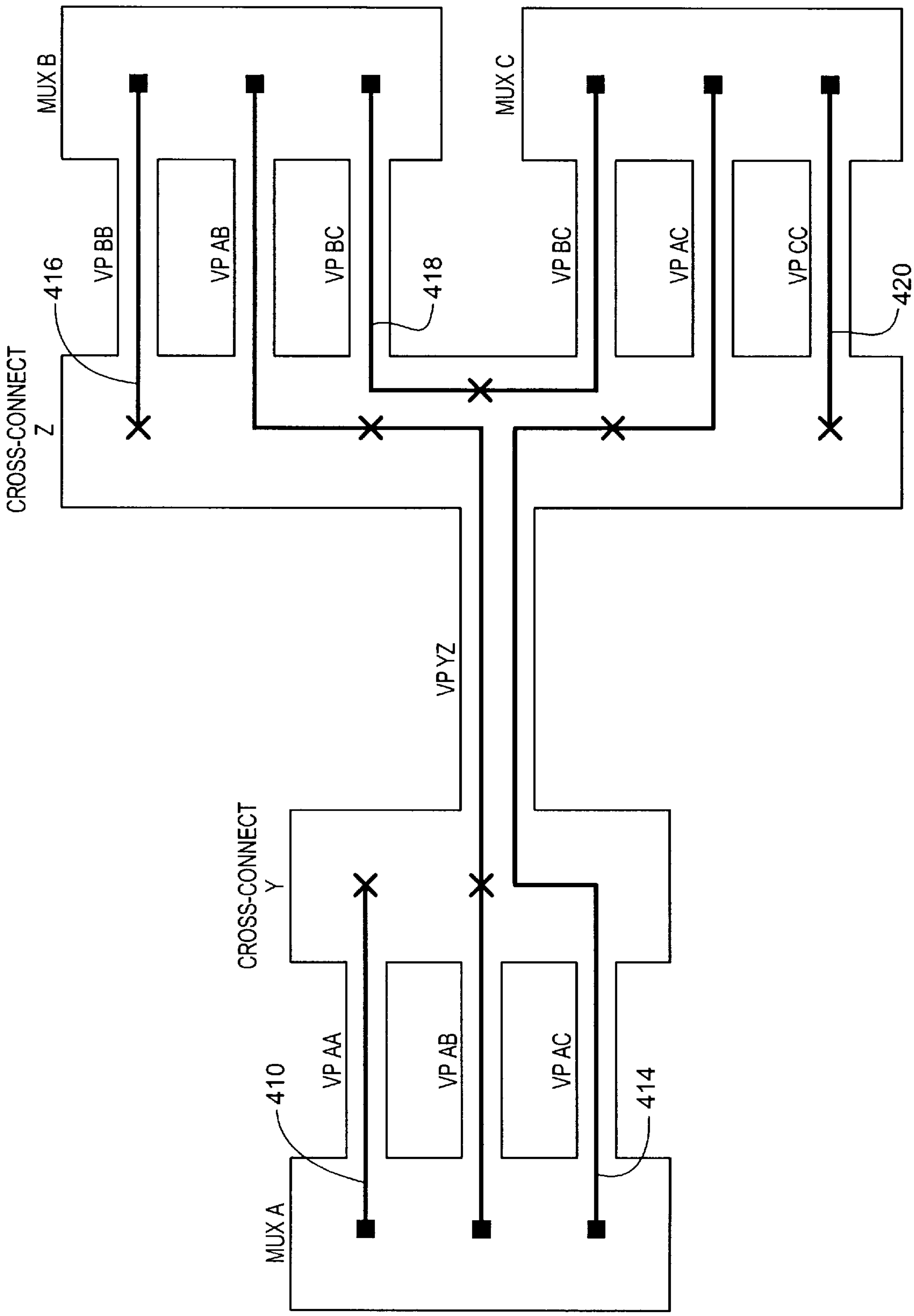

MUX B
MUX C
VP BB
VP AB
VP BC
418
VP BC
VP AC
VP CC
420
416
CROSS-CONNECT
Z
VP YZ
CROSS-CONNECT
Y
VP AA
VP AB
VP AC
410
414
MUX A

FIG. 4

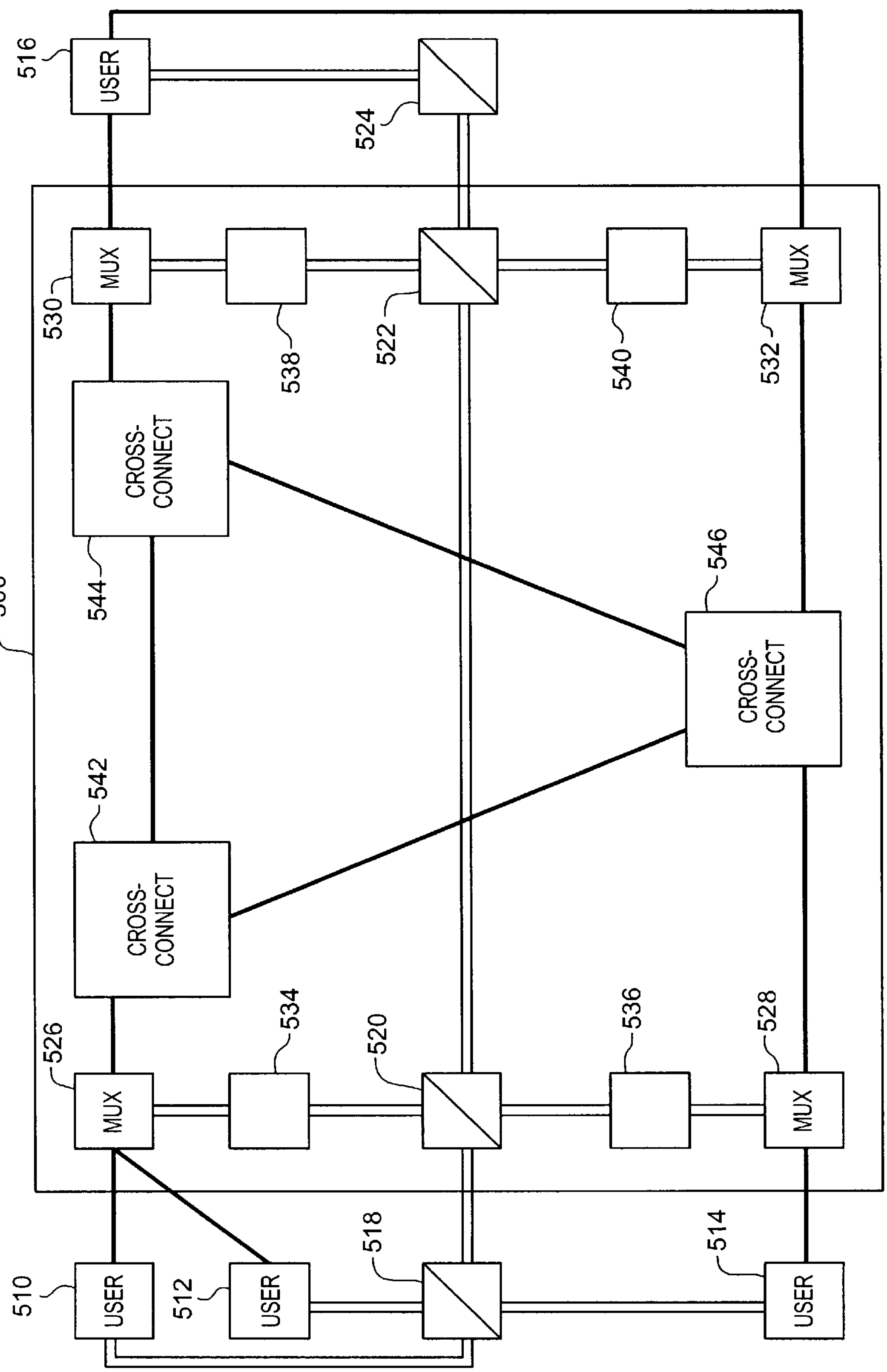

500
510
USER
512
USER
514
USER
516
USER
518
520
522
524
526
MUX
528
MUX
530
MUX
532
MUX
534
536
538
540
542
CROSS-CONNECT
544
CROSS-CONNECT
546
CROSS-CONNECT

FIG. 5

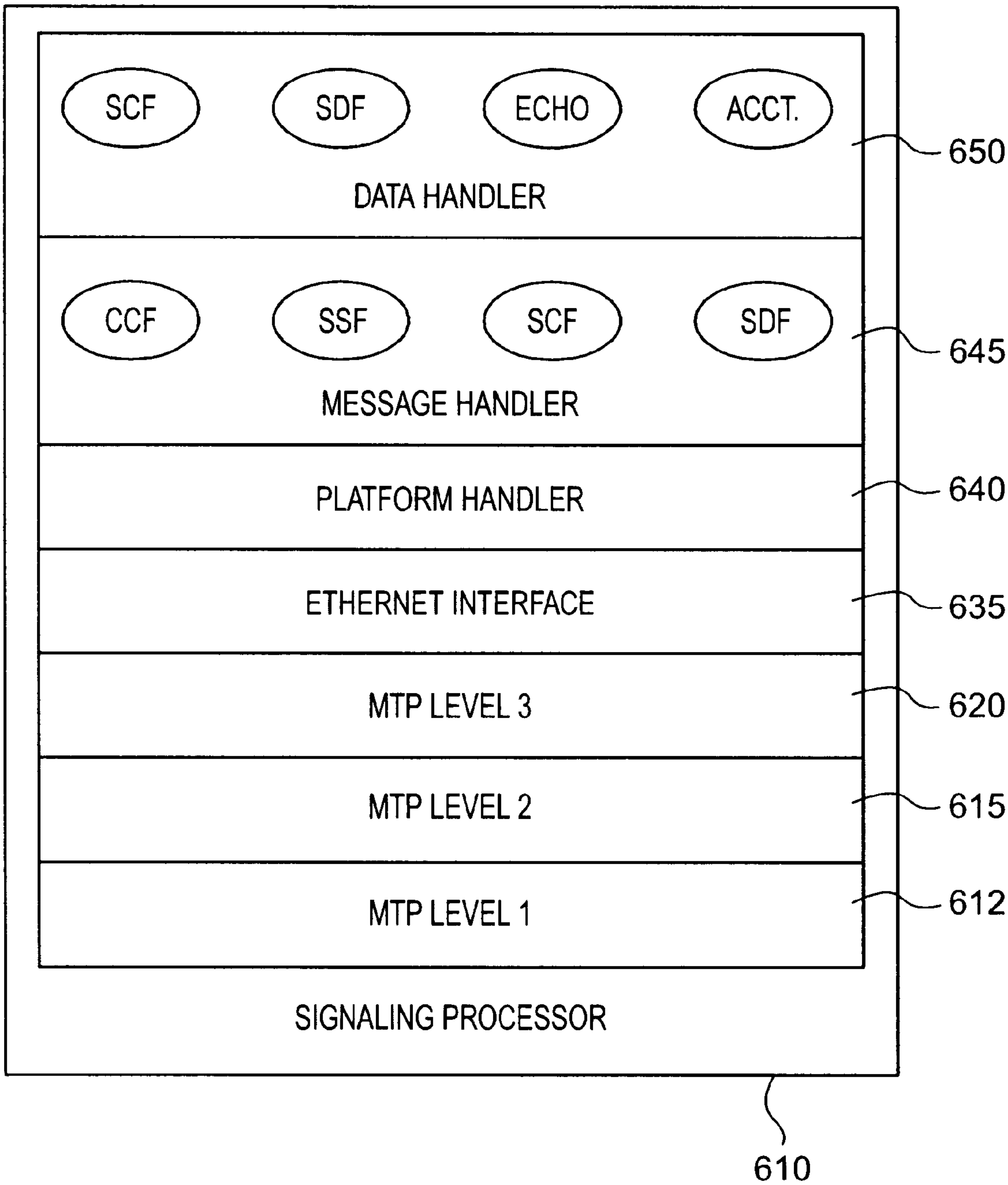

SCF
SDF
ECHO
ACCT.
DATA HANDLER
650
CCF
SSF
SCF
SDF
MESSAGE HANDLER
645
PLATFORM HANDLER
640
ETHERNET INTERFACE
635
MTP LEVEL 3
620
MTP LEVEL 2
615
MTP LEVEL 1
612
SIGNALING PROCESSOR
610

FIG. 6

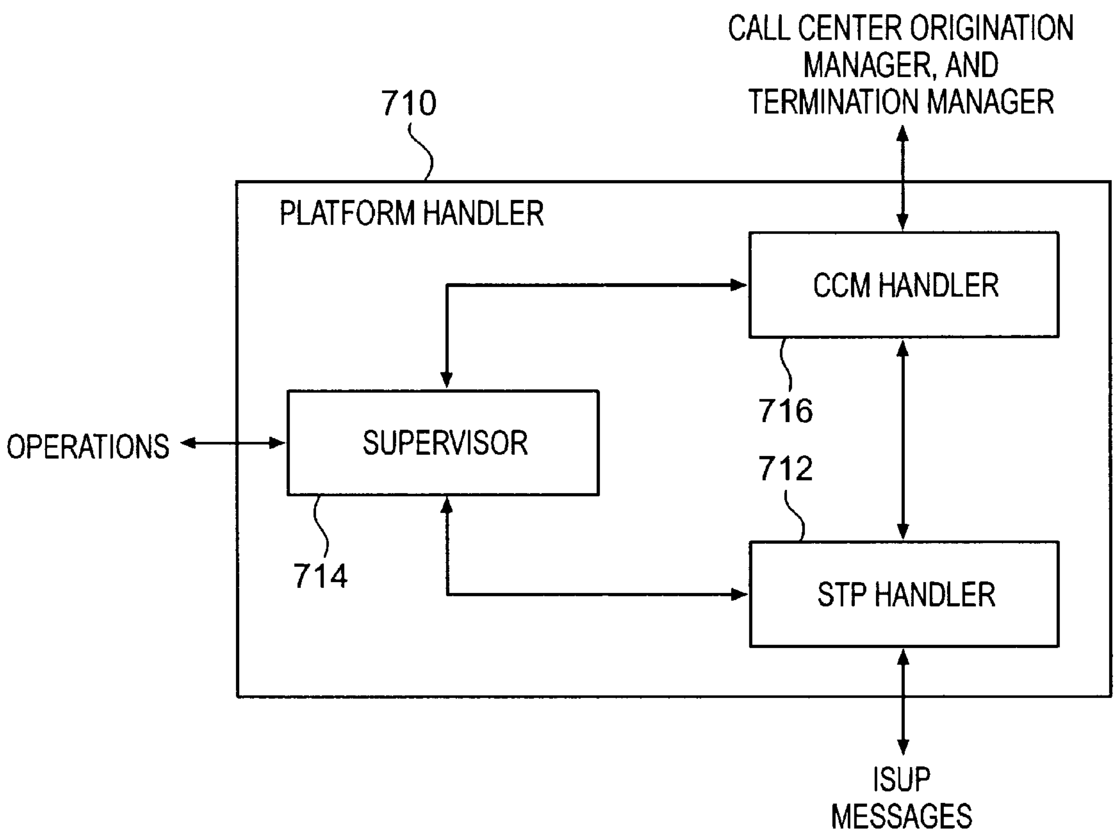
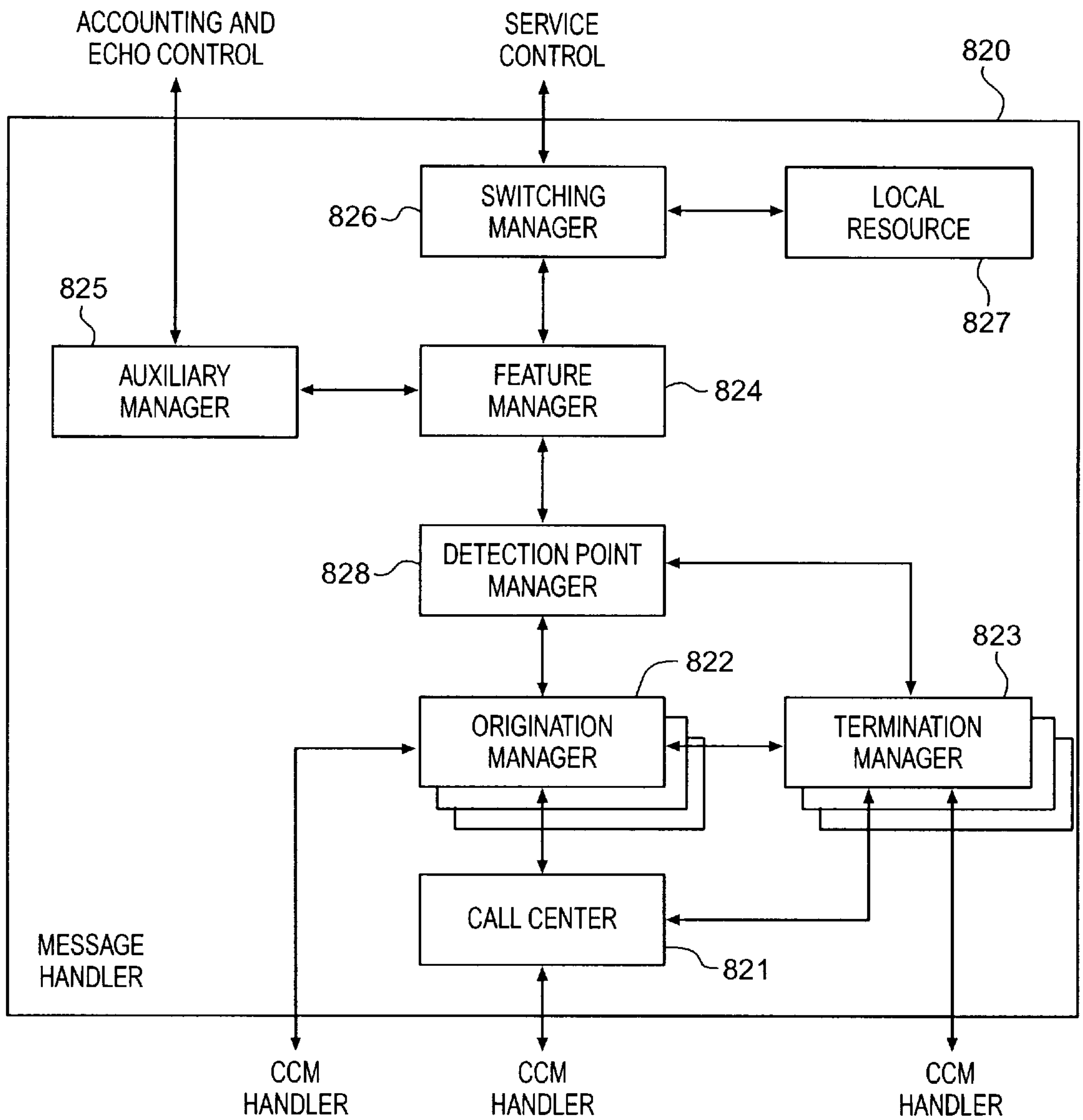

CALL CENTER ORIGINATION MANAGER, AND TERMINATION MANAGER
710
PLATFORM HANDLER
CCM HANDLER
716
OPERATIONS
SUPERVISOR
712
714
STP HANDLER
ISUP MESSAGES

FIG. 7



ACCOUNTING AND ECHO CONTROL
SERVICE CONTROL
820
SWITCHING MANAGER
826
LOCAL RESOURCE
827
825
AUXILIARY MANAGER
FEATURE MANAGER
824
DETECTION POINT MANAGER
828
822
823
ORIGINATION MANAGER
TERMINATION MANAGER
CALL CENTER
821
MESSAGE HANDLER
CCM HANDLER
CCM HANDLER
CCM HANDLER

FIG. 8

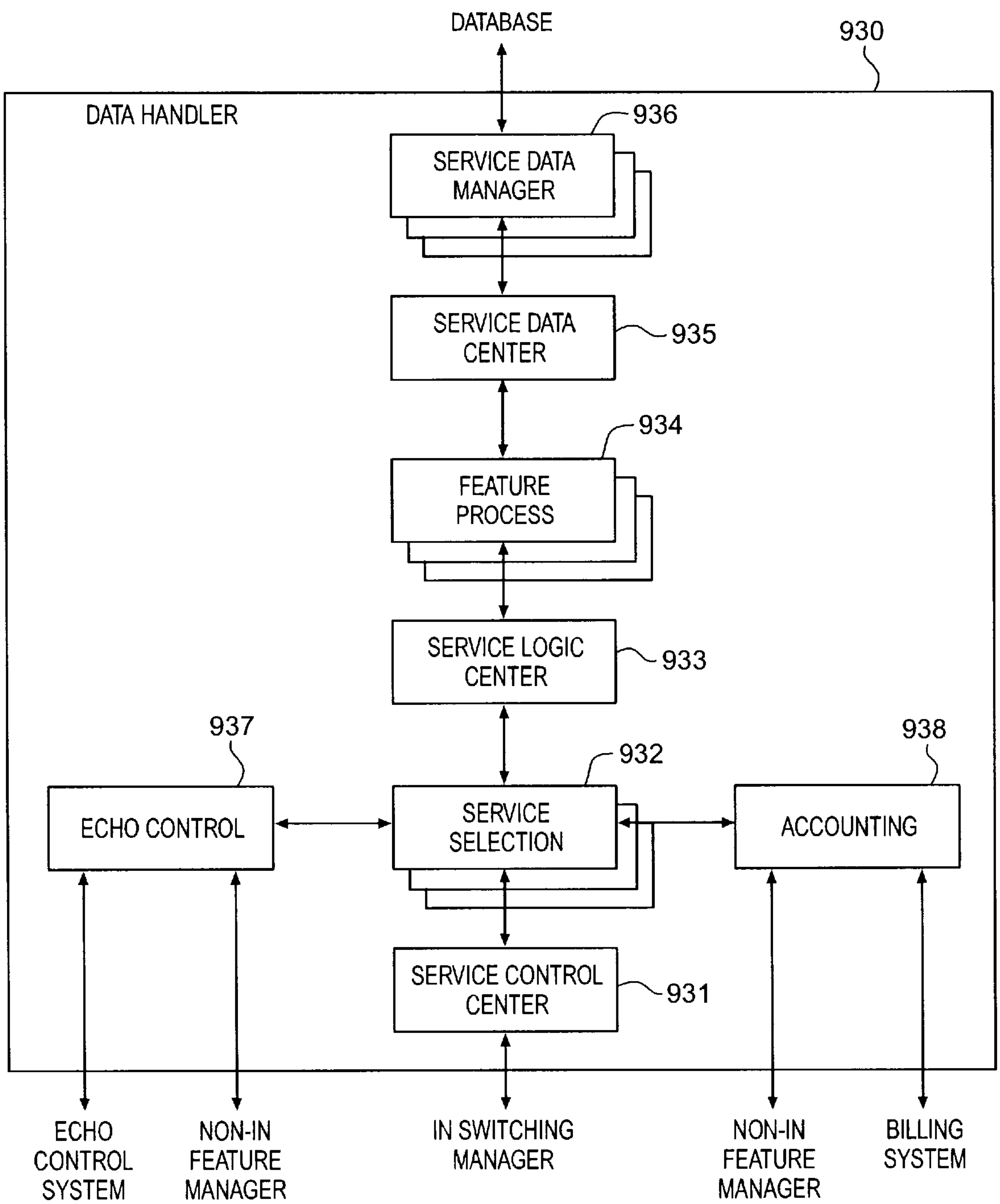

DATABASE
930
DATA HANDLER
936
SERVICE DATA MANAGER
SERVICE DATA CENTER
935
934
FEATURE PROCESS
SERVICE LOGIC CENTER
933
937
932
938
ECHO CONTROL
SERVICE SELECTION
ACCOUNTING
SERVICE CONTROL CENTER
931
ECHO CONTROL SYSTEM
NON-IN FEATURE MANAGER
IN SWITCHING MANAGER
NON-IN FEATURE MANAGER
BILLING SYSTEM

FIG. 9

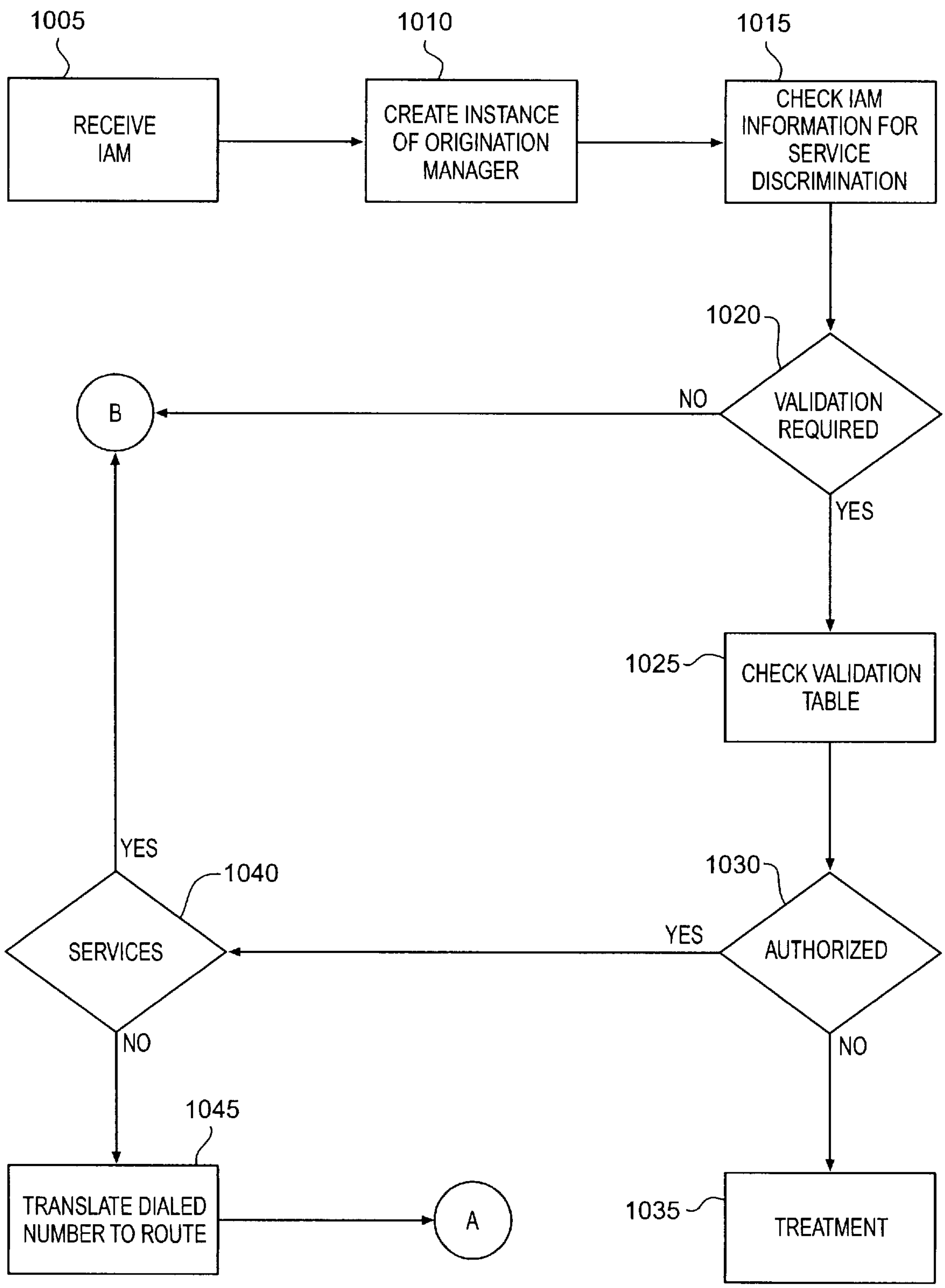

1005
RECEIVE IAM
1010
CREATE INSTANCE OF ORIGINATION MANAGER
1015
CHECK IAM INFORMATION FOR SERVICE DISCRIMINATION
1020
VALIDATION REQUIRED
NO
B
YES
1025
CHECK VALIDATION TABLE
1030
AUTHORIZED
YES
NO
1035
TREATMENT
1040
SERVICES
YES
NO
1045
TRANSLATE DIALED NUMBER TO ROUTE
A

FIG. 10

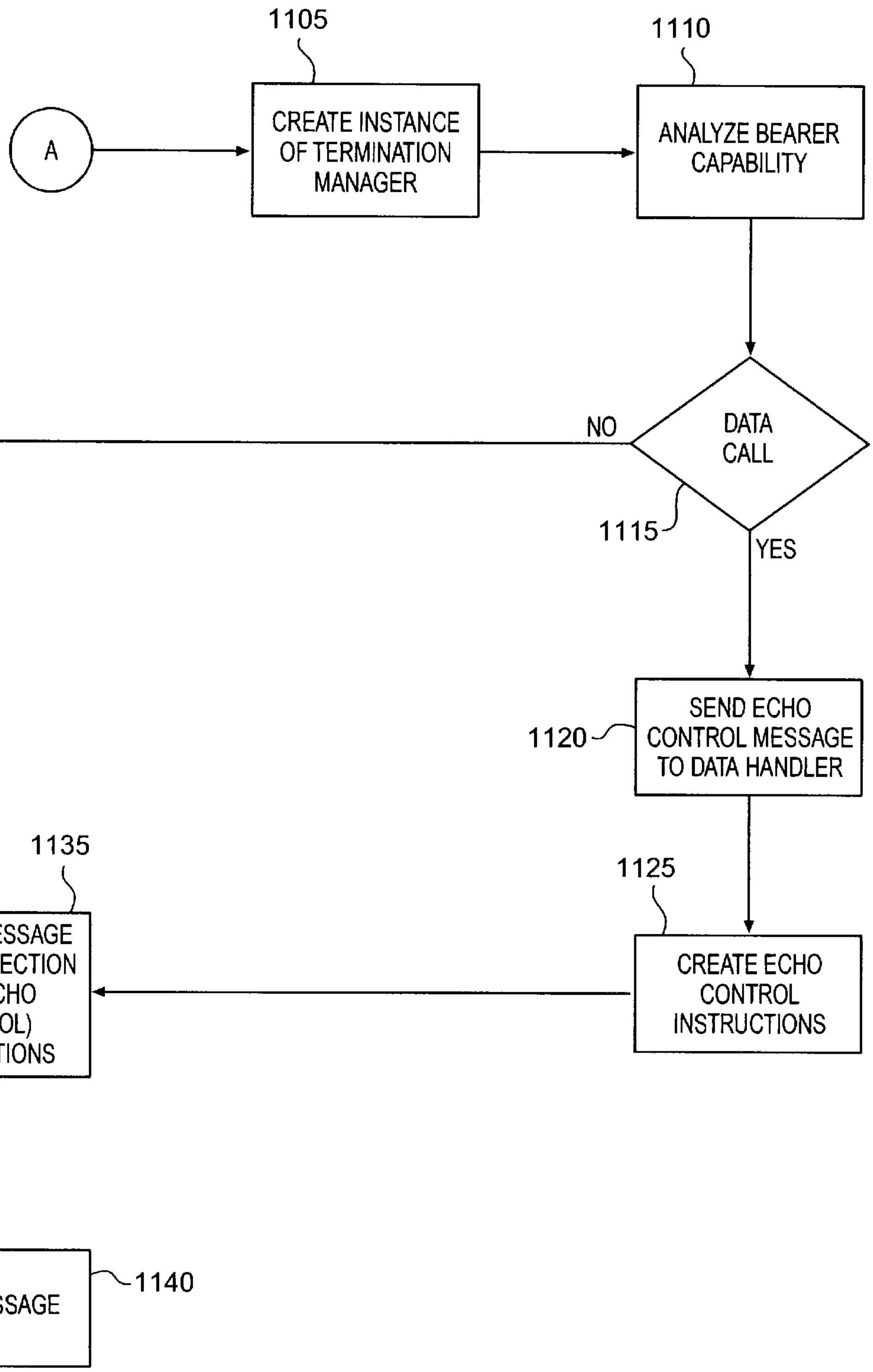

A
1105
CREATE INSTANCE OF TERMINATION MANAGER
1110
ANALYZE BEARER CAPABILITY
DATA CALL
1115
NO
YES
1120
SEND ECHO CONTROL MESSAGE TO DATA HANDLER
1125
CREATE ECHO CONTROL INSTRUCTIONS
1135
CREATE MESSAGE WITH CONNECTION (AND ECHO CONTROL) INSTRUCTIONS
1140
SEND MESSAGE

FIG. 11

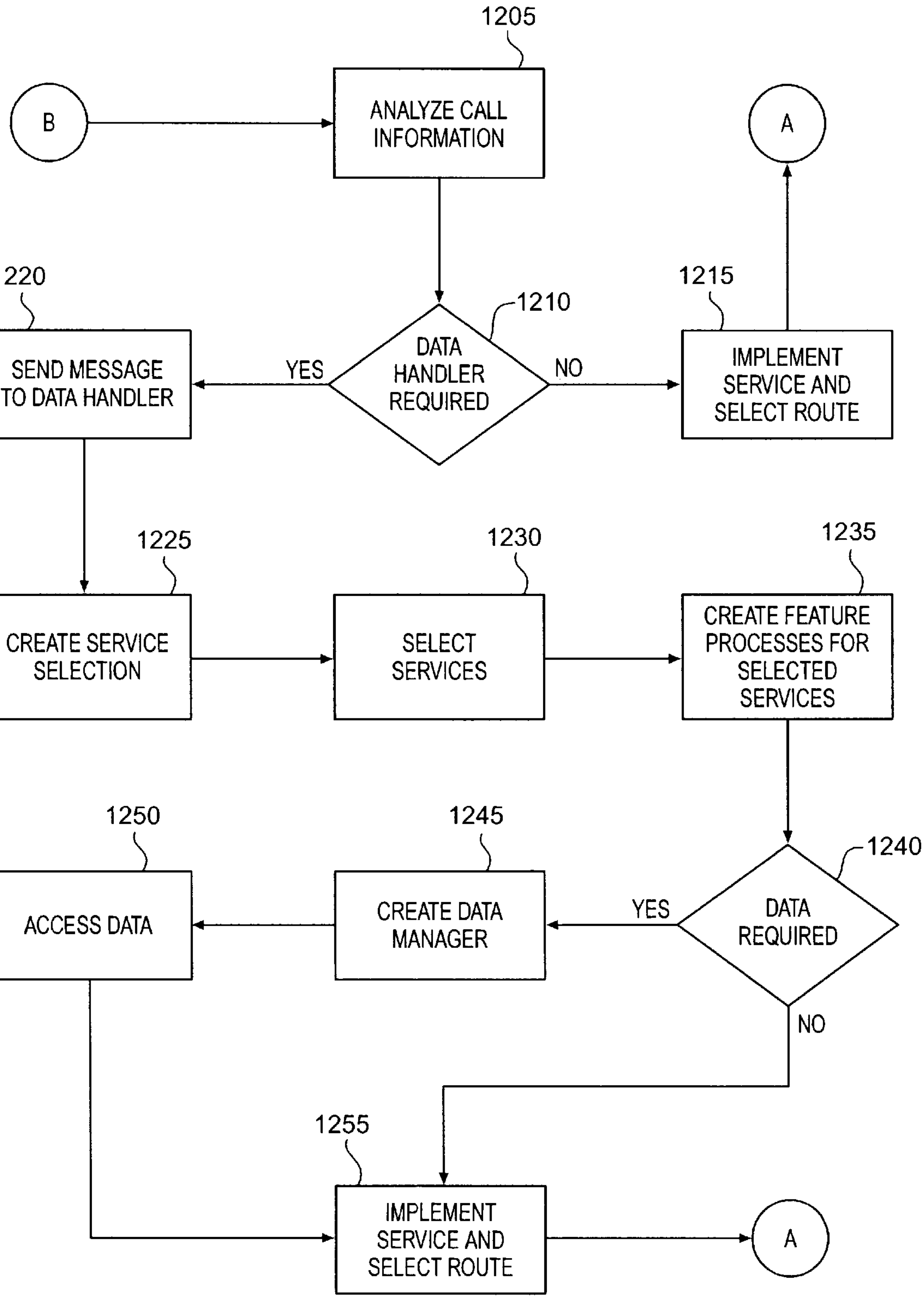

1205
B
ANALYZE CALL INFORMATION
A
1220
1215
1210
SEND MESSAGE TO DATA HANDLER
YES
DATA HANDLER REQUIRED
NO
IMPLEMENT SERVICE AND SELECT ROUTE
1225
1230
1235
CREATE SERVICE SELECTION
SELECT SERVICES
CREATE FEATURE PROCESSES FOR SELECTED SERVICES
1250
1245
1240
ACCESS DATA
CREATE DATA MANAGER
YES
DATA REQUIRED
NO
1255
IMPLEMENT SERVICE AND SELECT ROUTE
A

FIG. 12

BROADBAND TELECOMMUNICATIONS SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 08/525,897, entitled "Broadband Telecommunications System", filed on Sep. 8, 1995, now U.S. Pat. No. 5,991,301 which is incorporated by reference into this application, and which is a continuation-in-part of U.S. patent application Ser. No. 08/568,551, filed Dec. 7, 1995, now U.S. Pat. No. 5,825,780 entitled "Method, System, and Apparatus for Telecommunications Control", which is incorporated by reference into this application, and which is a continuation of U.S. patent application Ser. No. 08/238,605 filed May 5, 1994, abandoned.

BACKGROUND

At present, Asynchronous Transfer Mode (ATM) technology is being developed to provide broadband switching capability. Some ATM systems have used ATM cross-connects to provide virtual connections. Cross-connect devices do not have the capacity to process signaling. Signaling refers to messages that are used by telecommunications networks to set-up and tear down calls. Thus, ATM cross-connects cannot make connections on a call by call basis. As a result, connections through cross-connect systems must be pre-provisioned. They provide a relatively rigid switching fabric. Due to this limitation, ATM cross-connect systems have been primarily used to provide dedicated connections, such as permanent virtual circuits (PVCs) and permanent virtual paths (PVPs). But, they do not to provide ATM switching on a call by call basis as required to provide switched virtual circuits (SVCs) or switched virtual paths (SVPs). Those skilled in the art are well aware of the efficiencies created by using SVPs and SVCs as opposed to PVCs and PVPs. SVCs and SVPs utilize bandwidth more efficiently.

ATM switches have also been used to provide PVCs and PVPs. Since PVCs and PVPs are not established on a call-by-call basis, the ATM switch does need to use its call processing or signaling capacity. ATM switches require both signaling capability and call processing capability to provide SVCs and SVPs. In order to achieve virtual connection switching on a call by call basis, ATM switches are being developed that can process calls in response to signaling to provide virtual connections for each call. These systems cause problems because they must be very sophisticated to support current networks. These ATM switches must process high volumes of calls and transition legacy services from existing networks. An example would be an ATM switch that can handle large numbers of POTS, 800, and VPN calls. This generation of sophisticated ATM switches is not yet mature and should be expensive when they are first deployed.

Currently, ATM multiplexers are being developed that can interwork traffic into ATM cells and multiplex the cells for transport over an ATM network. One example of an application of these muxes is provided by T1 transport over an ATM connection. Traffic that leaves the switch in T1 format is muxed into ATM cells for transport over a high speed connection. Before the cells reach another switch, they are converted back into the T1 format. Thus, the ATM mux is used for high speed transport. The ATM mux is not used to select virtual connections on a call-by-call basis. Unfortunately, there is not a telecommunications system that can provide ATM switching on a call by call basis without relying on the call processing and signaling capability of an ATM switch.

SUMMARY

The invention includes a method of operating a telecommunications system to provide a call with a virtual connection. The method is for use when a user places the call by sending signaling for the call to the telecommunications system and by transmitting user information to the telecommunications system over a particular connection. The system comprises an ATM interworking multiplexer and a signaling processor linked to the ATM interworking multiplexer. The method comprises receiving the signaling for the call into the signaling processor, processing the signaling to select the virtual connection, generating new signaling to identify the particular connection and the selected virtual connection, and then transmitting the new signaling to the ATM interworking multiplexer. The method also includes receiving the user information for the call from the particular connection into the ATM interworking multiplexer, converting the user information into ATM cells that identify the selected virtual connection in response to the new signaling, and transmitting the ATM cells over the selected virtual connection. The signaling for the call could be a call set-up message, such a Signaling System #7 (SS7) initial address message (IAM). The method could also include applying digital signal processing (DSP) to the call in the multiplexer in accord with DSP requirements selected by the signaling processor. DSP requirements could include echo control or encryption.

The invention also includes a telecommunications system to provide a call with a virtual connection in response to signaling for the call. The system comprises a signaling processor to receive and process signaling to select the virtual connection for the call, and to generate and transmit new signaling that identifies the selected virtual connection. The system includes an ATM interworking multiplexer to receive user information from a connection, convert the user information into ATM cells that identify the selected virtual connection, and transmit the ATM cells over the selected virtual connection. The system could also include an ATM cross-connect system connected to the ATM interworking multiplexer and configured to provide a plurality of virtual connections to the ATM interworking multiplexer.

The invention also includes an ATM interworking multiplexer for providing calls with virtual connections in response to signaling for each of the calls. The multiplexer comprises an access interface to receive user information for each call from a particular connection. It also includes a control interface to receive signaling for each call that identifies the particular connection and a virtual connection for that call. It also includes an ATM adaption processor to convert user information from the particular connection for each call into ATM cells that identify the virtual connection for that call. The multiplexer also includes an ATM interface to transmit the ATM cells for each call over the virtual connection. The multiplexer could include a digital signal processor to apply digital signal processing to the user information for each call. The processing could include echo control and encryption.

In various embodiments, the invention accepts calls placed over DS0 voice connections and provides virtual connections for the calls. In this way, broadband virtual connections can be provided to narrowband traffic on a call-by-call basis without requiring the call processing and signaling capability of an ATM switch.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of a version of the present invention.

FIG. **2** is a block diagram of a version of the present invention.

FIG. **3** is a block diagram of a version of the present invention.

FIG. **4** is a block diagram of a version of the present invention.

FIG. **5** is a block diagram of a version of the present invention.

FIG. **6** depicts a logic diagram of a version of the invention.

FIG. **7** depicts a logic diagram of a version of the invention.

FIG. **8** depicts a logic diagram of a version of the invention.

FIG. **9** depicts a logic diagram of a version of the invention.

FIG. **10** depicts a flow diagram of a version of the invention.

FIG. **11** depicts a flow diagram of a version of the invention.

FIG. **12** depicts a flow diagram of a version of the invention.

DETAILED DESCRIPTION

For purposes of clarity, the term "connection" will be used to refer to the transmission media used to carry user traffic. The term "link" will be used to refer to the transmission media used to carry signaling. On the Figures, connections are shown by a single line and signaling links are shown by double lines.

FIG. **1** depicts a version of the present invention. Shown is telecommunications system **100**, user **110**, and user **120**. Telecommunications system **100** includes ATM interworking multiplexer (mux) **130**, mux **140**, ATM cross-connect system **150**, and signaling processing system **160**. User **110** is connected to mux **130** by connection **180**. Mux **130** and mux **140** are connected through cross-connect system **150** by connection **181**. Mux **140** is connected to user **120** by connection **182**. Signaling processing system **160** is linked to user **110** by link **190**, to mux **130** by link **191**, to mux **140** by link **192**, and to user **120** by link **193**.

Those skilled in the art are aware that large networks have many more components than are shown. For example, there would typically be a multitude of virtual connections through ATM cross-connect system **150**. The number of these components has been restricted for clarity. The invention is fully applicable to a large network.

User **110** and user **120** could be any entity that supplies telecommunications traffic to network **100**. Some examples would be a local exchange carrier (LEC) switch or customer premises equipment (CPE). Typically, the user traffic would be provided to system **100** in DS3, DS1, or OC-3 format that have embedded DS0 and VT 1.5 circuits. Connections **180** and **182** represent any connection that might be used by user **120** to access system **100** and would also include formats such as E1, E3, and DS2. As such, these connections are periodically referred to as access connections. Connections **180** and **182** would typically be DS0 connections embedded within a DS3 connection, however, the invention fully contemplates other connection being used with a few examples being a fractional DS1, a clear DS3, or even SONET OC-3. Links **190** and **193** are any links capable of transferring signaling messages with an example being Signaling System #7 (SS7) links. ATM cross-connect system **150** is any system that provides a plurality of virtual connections. Such a system could be comprised of individual ATM cross-connect devices interconnected by ATM connections using DS3 or SONET for transport. An example of an ATM cross-connect is the NEC Model 10. Connection **181** could be any virtual connection. Typically, the virtual connection would use DS3 or SONET for transport. ATM cross-connect system **150** would be pre-provisioned to provide a plurality of virtual connections through the cross-connect system, and virtual connection **181** represents one of these connections. As virtual connections are logical paths, many physical paths can be used based on the pre-provisioning of ATM cross-connect system **150**. Links **191** and **192** could be any links capable of transporting data messages. Examples of such links could be SS7 or UDP/IP. The components described in this paragraph are known in the art.

Signaling processing system **160** is any processing platform that can receive and process signaling to select virtual connections, and then generate and transmit signaling to identify the selections. Various forms of signaling are contemplated by the invention, including SS7, C7, and user to network interface (UNI) signaling. A preferred embodiment of the signaling processor is discussed in detail toward the end of the disclosure.

Mux **130** could be any muxing system operable to place user information arriving over connection **180** on the virtual connection selected by signaling processing system **160**. Typically, this involves receiving signaling messages from signaling processing system **160** that identify assignments of virtual connections to an access connection on a call by call basis. The mux would convert user traffic from access connection **180** into ATM cells that identify the selected virtual connection. Mux **140** is similar to mux **130**. A preferred embodiment of these muxes are also discussed in detail below.

The system would operate as follows for a call from user **110** to user **120**. User **110** would send a signaling message over link **190** to system **100** initiating the call. Signaling processing system **160** would process the message. Such processing could include validation, screening, translating, route selection, echo control, network management, signaling, and billing. In particular, a virtual connection through ATM cross-connect system **150** from mux **130** to mux **140** would be selected, and a connection from mux **140** to user **120** would also be selected. Although many possible connections would be available, only the selected connections are shown—connection **181** and connection **182**. Generally, the selection is based on the dialed number, but call processing can entail many other factors with a few examples being network loads and user routing instructions. Signaling processing system **160** would then send signaling reflecting the selections to mux **130** and mux **140**.

User **110** would also seize a connection to system **100**. The connection is represented by connection **180** to mux **130**. Although, only one connection is shown for purposes of clarity, numerous connections would typically be available for seizure. The seized connection would be identified in the signaling from user **110** to system **100**. Signaling processing system **160** would include the identity of this connection in its signal to mux **130**.

If required, user **120** would receive signaling to facilitate completion of the call. The signaling from signaling pro-

cessing system **160** would indicate that system **100** was connecting to user **120** over connection **182**. Typically, user **120** would accept and acknowledge the connection in a signaling message back to system **100**.

Mux **130** would receive signaling from signaling processing system **160** identifying connection **180** as the access connection and connection **181** as the selected virtual connection through ATM cross-connect system **150**. Mux **130** would convert the user information from connection **180** into ATM cells. Mux **130** would designate connection **181** in the cell headers. Connection **181** would have been previously provisioned through ATM cross-connect system **150** from mux **130** to mux **140**.

Mux **140** would receive signaling from signaling processing system **160** identifying connection **181** as the selected virtual connection and connection **182** as the selected access connection to user **120**. Mux **140** would convert cells arriving on connection **181** to user information suitable for connection **182** to user **120**. Although the above example employs two muxes, a single mux could be employed for calls that enter and exit system **100** through the same mux. In this case, the ATM system would simply provide a virtual connection back to the same mux.

From the above discussion, it can be seen that multiple virtual connections can be pre-provisioned through an ATM cross-connect system to interconnect ATM interworking multiplexers. When a user places a call, one of the virtual connections is selected for the call by the signal processing system and identified to the appropriate muxes. The muxes convert the user information into cells that identify the selected connection. As such, user information can be switched through an ATM fabric on a call by call basis. The system does not require the call processing or signaling capabilities of an ATM switch (although an ATM switch could be used to provide the virtual connections without using its call processing and signaling functions). The system can also implement enhanced services such as N00 and virtual private network (VPN).

FIG. **2** depicts another embodiment of the invention. In this embodiment, the user information from the access connection is capable of being muxed to the DS0 level, but this is not required in other embodiments. Additionally, SS7 signaling is used in this embodiment, but other signaling protocols, such as C7 or UNI signaling, are also applicable to the invention.

Shown are DS0 interface **210**, ATM adaption layer (AAL) **220**, ATM interface **230**, DS0—virtual connection assignment **240**, call/connection manager (CCM) **250** and signal transfer point (STP) **260**. Also shown are connections **280–283** and links **290–292**.

Connection **280** could by any connection or group of connections that contain information that can be converted to DS0 format. Examples of these connections are OC-3, VT1.5, DS3, and DS1. DS0 interface **210** is operable to convert user information in these formats into the DS0 format. AAL **220** comprises both a convergence sublayer and a segmentation and reassembly (SAR) layer. AAL **220** is operational to accept the user information in DS0 format from DS0 interface **210** and convert the information into ATM cells. AALs are known in the art and information about AALs is provided by International Telecommunications Union (ITU) document I.363.1. An AAL for voice is also described in patent application Ser. No. 08/395,745, filed on Feb. 28, 1995, entitled “Cell Processing for Voice Transmission”, and hereby incorporated by reference into this application. ATM interface **230** is operational to accept

ATM cells and transmit them over connection **283**. Connection **283** is a standard DS3 or SONET connection transporting ATM cells. Connection **281** is operational for the DS0 format and connection **282** is operational to transfer ATM cells.

It can be seen that a communications path through connections **280–283** could be established to carry user information. Although the communications path has been described from connection **280** to connection **283**, the invention contemplates components that are also operational to perform reciprocal processing in the reverse direction. If the communications path is bidirectional, user information in ATM cells arriving on connection **283** would be processed for output on connection **280** in the appropriate format. Those skilled in the art will appreciate that separate connections could also be set up in each direction, or that only a connection in one direction may be required. These components and their operation are known in the art.

Signaling links **290** and **291** are SS7 links. Link **292** is a data link with an example being an ethernet connection transporting UDP/IP. STP **260** is device that routes signaling messages. STPs are well known in the art. CCM **250** would be identified by its own signaling point code. STP **260** would route signaling messages addressed to this point code to CCM **250**. In some embodiments, STP **260** may also convert other point codes to the point code for CCM **250** so these signaling messages are also routed to CCM **250**. Although point code conversion is not essential, it facilitates the transition of a network to the system of the invention. The conversion could be implemented through a conversion table located between level **2** and level **3** of the message transfer part (MTP) function of STP **260**. The conversion table would convert the destination point code of the message to that of CCM **250**, so that the route function of MTP **3** would forward the message to CCM **250**. Point code conversion could be based on many factors with a few examples being the destination point code, the origination point code, the signaling link, the circuit identification code, the message type, and various combinations of these and other factors. For example, SS7 Integrated Services User Part (ISUP) messages with particular OPC/DPC combinations could have the DPC converted to the point code of CCM **250**. These signaling messages would then be routed to CCM **250** by STP **260**. One version of a suitable STP is disclosed in United States patent application entitled “Telecommunications Apparatus, System, and Method with Enhanced Signal Transfer Point”, filed simultaneously with this application, assigned to the same entity, and hereby incorporated by reference into this application.

CCM **250** is a signaling processor that operates as discussed above. A preferred embodiment of CCM **250** is provided later. In this embodiment CCM **250** would be operable to receive and process SS7 signaling to select connections, and to generate and transmit signaling identifying the selections.

Assignment **240** is a control interface that accepts messages from CCM **250**. In particular, assignment **240** identifies DS0/virtual connection assignments in the messages from link **292**. These assignments are provided to AAL **220** for implementation. As such, AAL **220** obtains the virtual path identifier (VPI) and virtual channel identifier (VCI) for each call from assignment **240**. AAL **220** also obtains the identity of the DS0 for each call (or the DS0s for an N×64 call). AAL **220** then converts user information between the identified DS0 and the identified ATM virtual connection. Acknowledgments that the assignments have been implemented may be sent back to CCM **250** if desired.

In operation, calls are processed as follows. Signaling messages for calls arrive on link **290** and are routed by STP **260** to CCM **250**. Access connections are typically seized contemporaneously with the signaling. All of these connections are represented by connection **280**. DS0 interface **210** would convert the traffic on connection **280** into the DS0 format and provide the DS0s to AAL **220** over connection **281**.

The signaling received by CCM **250** would identify the access connections for the calls (i.e. the particular DS0s on connection **280**), and contain call information, such as a dialed number. CCM **250** would process the signaling and select connections for the call. Since multiple virtual connections are pre-provisioned from ATM interface **230** to the other destinations in the network, CCM **250** can select a virtual connection to the destination. The selection process can be accomplished through table look-ups. For example, a table could be used to translate a portion of the dialed number into a VPI. The VCI would be selected based on the available VCIs in the selected VPI. The VPI/VCI combination would correspond to a unique virtual connection pre-provisioned from ATM interface **230** to the appropriate network destination. The selections represent the DS0—virtual connection assignments that are provided to assignment **240** over link **292**.

Assignment **240** accepts the DS0—virtual connection assignments and provides them to AAL **220**. When AAL **220** receives a particular assignment, it converts user information from the designated DS0 into cells that identify the designated VPI/VCI. The cells are provided to ATM interface **230** over connection **282**. ATM interface **230** accepts the cells and places them within the transport format for connection **283**. The cells are then transported over the selected virtual connection to the appropriate destination.

Calls also exit the network through connection **280**. In this case, CCMs at the origination points select the virtual connections to ATM interface **230**. The originating CCMs also send signaling messages to CCM **250**. The signaling messages identify the destinations for the calls and the selected virtual connections. CCM **250** will have a list of available access connections to the identified destinations. CCM **250** will select the access connections to the destination from the list. For example, the connection selected by CCM **250** could be a DS0 embedded within a DS3 connected to a LEC. The virtual connections on connection **283** and selected access connections on connection **280** are provided to assignment **240** over link **292**. Assignment **240** provides these assignments to AAL **220**.

ATM interface **230** will demux the cells arriving from connection **283** and provide them to AAL **220**. AAL **220** converts the user information in the cells into the DS0 format. AAL **220** make the conversion so that cells from a particular virtual connection are provided to the assigned DS0 on connection **281**. DS0 interface will convert the DS0s from connection **281** into the appropriate format, such as DS3, for connection **280**. Those skilled in the art are aware of the techniques for muxing and transporting DS0 signals.

From the above discussion, it can be seen that user information for calls can flow from connection **280** to connection **283**, and in the reverse direction from connection **283** to connection **280**. DS0 interface **210** and ATM interface **230** provide user information in their respective formats to AAL **220**. AAL **220** converts the user information between DS0 and ATM formats based on the assignments from assignment **240**. CCM **250** can select the DS0—virtual connection assignments that drive the process.

The ATM Interworking Multiplexer

FIG. **3** shows one embodiment of the mux that is suitable for the present invention, but muxes that support the requirements of the invention are also applicable. Shown are control interface **300**, OC-3 interface **305**, DS3 interface **310**, DS1 interface **315**, DS0 interface digital signal processing(DSP) **325**, AAL **330**, and OC-12 interface **335**.

OC-3 interface **305** accepts the OC-3 format and makes the conversion to DS3. DS3 interface **310** accepts the DS3 format and makes the conversion to DS1. DS3 interface **310** can accept DS3s from OC-3 interface **305** or from an external connection. DS1 interface **315** accepts the DS1 format and makes the conversion to DS0. DS1 interface **315** can accept DS1s from DS3 interface **310** or from an external connection. DS0 interface **320** accepts the DS0 format and provides an interface to digital signal processing (DSP) **325**.

DS0 interface **320** is coupled to DSP **325**. DSP **325** is capable of manipulating the user information to improve transmission quality. DSP processing primarily entails echo cancellation, but could include other features as well. As is known, echo cancellation can be required for voice calls. DSP **325** passes the DS0s through echo cancellers. These echo cancellers must be disabled for calls that do not require echo control. Data calls do not require echo cancellation, and the CCM has the ability to recognize data calls that require an echo canceller to be disabled. The CCM will send a control message through control interface **300** to DSP **325** indicating the particular echo canceller that is to be disabled. The CCM selects the echo canceller based on the CIC in the signaling it receives from the user. After the data call, the CCM sends a message that causes the particular echo canceller to be enabled again for subsequent voice calls. The above technique of applying echo control is preferred, but other means of implementing echo control instructions from the CCM are also applicable.

In addition to echo control, the CCM and the mux can work to provide other digital signal processing features on a call by call basis. Compression algorithms can be applied, either universally, or on a per call basis. The decibel level could be adjusted for calls form a particular origin or to a particular destination, i.e. where a hearing impaired person may reside. Encryption could be applied on a call-by-call basis based on various criteria like the origination number or the destination number. Various DSP features could be associated with various call perameters and implemented by the CCM through DSP **325**.

DSP **325** is connected to AAL **330**. AAL **330** operates as described above for an AAL. DS0—virtual connection assignments from control interface **300** are implemented by AAL **330** when converting between the DS0 and ATM formats.

Calls with a bit rate greater than 64 kbit/sec. are known as N×64 calls. If desired, AAL **330** can be capable of accepting control messages through control interface **300** from the CCM for N×64 calls. The CCM would instruct AAL **330** to group the DS0s for the call.

The ATM Cross-connect System

FIG. **4** depicts virtual connections provided by the ATM cross connect system in a version of the invention, although numerous other techniques for providing virtual connections will be appreciated by one skilled in the art, and the invention contemplates any such system. Shown are virtual connections **410**, **412**, **414**, **416**, **418**, and **420**. These virtual connections are shown interconnecting muxes A, B, and C

through cross-connects Y and Z. Virtual connections are provisioned in between each mux. Each mux would have a virtual path to the cross-connect system that is designated for each possible destination mux. Virtual path AB contains virtual connection **412** from mux A to mux B. For calls that originate and terminate at the same mux, virtual connections **410**, **416**, and **420** are provisioned for that purpose. Virtual connections **414** and **418** connect muxes A/C and B/C respectively. Alternate routes for different virtual connections can be provisioned between the same two muxes.

Within each virtual path are thousands of virtual channels (not shown). Virtual connections are provisioned by cross-connecting VPI/VCI combinations at cross-connects Y and Z. If a call enters mux A and needs to terminate at mux B, the CCM will select virtual path AB. The selection could be based on a translation of the dialed number. Within virtual path AB, the CCM would select the particular virtual channel. This selection could be based on available VCIs within the VPI. In this way, pre-provisioned virtual connections can be selected on a call by call basis.

Typically, calls will require a bidirectional voice connection. For this purpose, a virtual connection must transport user information in both directions. The virtual connections can be provisioned so that the mux at the terminating end may use the same VPI/VCI for cells transported in the opposite direction. The terminating CCM could also translate the originating VPI/VCI into another VPI/VCI provisioned in the opposite direction and provide this VPI/VCI to the terminating mux.

Additionally, the number of active virtual connections in between cross-connects can be tracked. Virtual path YZ connects cross-connects Y and Z. The capacity of virtual path YZ would be sized based on network requirements, but should it become overloaded, the CCMs can be programmed to select an alternate virtual path.

Operation Within a Network

FIG. **5** depicts an embodiment of the invention with respect to a specific telecommunications network scenario, although the invention is not limited to this specific scenario. FIG. **5** shows telecommunications system **500**. Shown are user **510**, user **512**, user **514**, user **516**, STP **518**, STP **520**, STP **522**, STP **524**, mux **526**, mux **528**, mux **530**, mux **532**, call/connection manager (CCM) **534**, CCM **536**, CCM **538**, CCM **540**, ATM cross-connect **542**, ATM cross-connect **544**, and ATM cross-connect **546**. For clarity, the connections and signaling links are not numbered. All of these components are described, and the CCMs are also discussed below.

In operation, user **510** may forward an 800 call to system **500**. User **510** could be connected to mux **526** with a DS3 connection. The 800 call would occupy a DS0 embedded in the DS3 connected to mux **526**. User **510** would send an SS7 Initial Address Message (IAM) through STP **518** to system **500**. STP **520** would be configured to route the IAM to CCM **534**. An IAM contains information such as the dialed number, the caller's number, and the circuit identification code (CIC). The CIC identifies the DS0 used by user **510** for the call.

CCM **534** would process the IAM and identify that the call was an 800 call. Either through its own database or by accessing a service control point (SCP) (not shown), the CCM would translate the dialed number based on the 800 subscriber's routing plan. For example, 800 calls from user **510** may be routed to user **512** during business hours, to user **514** at night, and to user **516** on weekends. If the call is placed from user **512** on a weekend, the call would be routed to user **516**. As such, CCM **534** would select a pre-provisioned virtual connection from mux **526** through ATM cross-connect **542** and ATM cross-connect **544** to mux **530**. CCM **534** would send an IAM message to CCM **538** through STP **520** and STP **522**. The IAM would indicate that a call was being routed to user **516** and would identify the selected virtual connection being used to reach mux **530**.

Typically, mux **530** would be connected to user **516** with a DS3 connection. CCM **538** would select a DS0 embedded in the DS3 and would send an IAM to user **516** through STP **522** and STP **524**. The CIC of the IAM would indicate that a call was being routed to user **516** over the selected DS0. User **516** would process the IAM and complete the call. When the call is answered, user **516** would transmit an answer message (ANM) through STP **524** back to system **500**.

CCM **534** would also send a UDP/IP message to mux **526** instructing it to assemble the user information in the DS0 from user **510** into ATM cells with a cell header identifying the selected virtual connection. CCM **538** would send a UDP/IP message to mux **530** instructing it to dis-assemble ATM cells from the selected virtual connection and output the user information to the selected DS0 to user **516**. ATM cross-connect **542** would route ATM cells from mux **526** to ATM cross-connect **544** based on the cell header. Likewise, ATM cross-connect **544** would route these cells to mux **530** based on the cell header. As such, user information for the call would flow from user **510** to user **516** over the DS0 from user **510**, the virtual connection selected by CCM **534**, and the DS0 to user **516** selected by CCM **538**. The muxes would implement the selections of the CCMs.

The call would require that a voice channel be available in both directions. As such, the DS0s and virtual connection would be bi-directional. Cut-through on the receive channel (from the user **516** to the user **510**) would occur after the address complete message (ACM) had been received by system **500**. Cut-through on the transmit channel (from the user **510** to the user **516**) would occur after the answer message (ANM) had been received by system **500**. This could be accomplished by not allowing mux **530** to release any cells for the call until the ANM has been received by system **500**.

If user **510** were to place the call at night, CCM **534** would determine that user **514** was the destination. Accordingly a pre-provisioned virtual connection from mux **526** through ATM cross-connect **542** and ATM cross-connect **546** to mux **528** would be selected for the call. CCM **536** would select the DS0 to user **514**.

If user **510** were to place the call during the day, CCM **534** would determine that user **512** was the destination. Accordingly a pre-provisioned virtual connection from mux **526** through ATM cross-connect **542** and back to mux **526** would be selected for the call. CCM **534** would also select the DS0 to user **512**.

The Call/Connection Manager (CCM)

FIGS. **6–12** refer to a preferred embodiment of the signaling processor, also known as the CCM, but any processor which supports the requirements stated for the invention would suffice. FIG. **6** depicts a signaling processor suitable for the invention. Signaling processor **610** would typically be separate from the mux, but those skilled in the art appreciate that they could be housed together. Also, signaling processor may support a single mux or support multiple muxes.

Signaling processor **610** includes Message Transfer Part (MTP) level **1** **612**, MTP level **2** **615**, and MTP level **3** **620**.

MTP level **1 612** defines the physical and electrical requirements for a signaling link. MTP level **2 615** sits on top of level **1** and maintains reliable transport over a signaling link by monitoring status and performing error checks. Together, MTP levels **1–2** provide reliable transport over an individual link. A device would need MTP level **1–2** functionality for each link it uses. MTP level **3 620** sits on top of level **2** and provides a routing and management function for the signaling system at large. MTP level **3 620** directs messages to the proper signaling link (actually to the MTP level **2** for that link). MTP level **3 620** directs messages to applications using the MTP levels for access the signaling system. MTP level **3 620** also has a management function which monitors the status of the signaling system and can take appropriate measures to restore service through the system. MTP levels **1–3** correspond to layers **1–3** of the open systems interconnection basic reference model (OSIBRF). Both the MTP **1–3** and the OSIBRF are well known in the art

Also shown for signaling processor **610** are ethernet interface **635**, platform handler **640**, message handler **645**, and data handler **650**. Ethernet interface **635** is a standard ethernet bus supporting TCP/IP which transfers signaling messages from MTP level **3** to platform handler **640**. Also, if UDP/IP is used to communicate with the muxes, ethernet interface **335** would accept the links to the muxes. Those skilled in the art will recognize other interfaces and protocols which could support these functions in accord with the invention.

In accord with this invention, the logic of the signaling interface (indicated by reference numerals **612**, **615**, **620**, and **635**) would be operational to route select ISUP messages to platform handler **640**. Technique for doing this have been discussed above. Preferably, an SS7 interface to platform handler **640** could be constructed using commercially available SS7 software interface tools. An example of such tools would be SS7 interface software provided by Trillium, Inc.

Platform handler **640** is a system which accepts ISUP and B-ISUP messages from ethernet interface **635** and routes them to message handler **645**. Preferably, platform handler **640** is configured to route messages to a particular message handler processor based on the signaling link selection (SLS) code in the message. Message handler **645** is a system which exchanges signaling with platform handler **640** and controls the connection and switching requirements for the calls. It can select and implement services and initiate echo control. It also converts signaling between ISUP and B-ISUP. Data handler **650** is a set of logic coupled to message handler **645** which processes service requests and provides data to message handler **645**. Data handler **650** also controls echo cancellers and generates billing records for the call.

In the discussions that follow, the term ISUP will include B-ISUP as well. In operation, ISUP messages that meet the proper criteria are routed by MTP and/or ATM interface **615**, MTP level **3 620**, and ethernet interface **635** to platform handler **640**. Platform handler **640** would route the ISUP messages to message handler **645**. Message handler **645** would process the ISUP information. This might include validation, screening, and determining if additional data is needed for call processing. If so, data handler **650** would be invoked and would provide message handler **645** with the relevant data so message handler **645** could complete call processing. Message handler **645** would generate the appropriate ISUP message to implement the call and pass the signals to platform handler **640** for subsequent transmission to the designated network elements.

The distribution of functional entities among message handler **645** and data handler **650** are shown. These functional entities are well known in the art. Message handler **645** includes at least the call control function (CCF) and the service switching function (SSF). The CCF establishes and releases call connections, and the SSF recognizes triggers during call processing by the CCF and provides an interface between the CCF and the service control function (SCF). The SCF identifies services and obtains data for the service. In some embodiments, message handler **645** can include the SCF and the service data function (SDF). The SDF provides service data in real time to the SCF. Taken together, message handler **645** is able to at least control connections and recognize triggers. In some embodiments, message handler **645** can also identify services, obtain data for the services, and generate the signaling required to implement the services. Message handler **645** can provide signaling interworking (i.e. ISUP to B-ISUP), connection control, service selection and service implementation in a logically integrated package that interfaces with the network through conventional means.

Data handler **650** includes at least the SCF and the SDF. In some embodiments, message handler **645** and data handler **650** both include the SCF and the SDF and services are partitioned among the functional entities. Two other functions are shown in data handler that are not standardized functional entities. Accounting generates a billing record and echo handles the echo cancellers. Typically, an echo canceller is disabled for a data call and enabled after the data call for use on subsequent voice calls, however, other techniques are applicable.

In operation, the CCF would perform basic call processing until the SSF recognized a trigger and invoked the SCF. The SCF would identify the service associated with the trigger. The SCF would access data from the SDF in order to implement the service. The SCF would process the data from the SDF and provide the data to the CCF through the SSF. The CCF would then set-up the connections through conventional signaling to service switching points (SSPs). The SSPs are connected to the communications path and make the connections. Typically, an SSP is a switch. Also, echo cancellers may be controlled for the call, and a billing record could be generated for the call.

Those skilled in the art are aware of various hardware components which can support the requirements of the invention. For example, the platform handler, message handler, and data handler could each reside on a separate SPARC station **20**.

The Platform Handler

FIG. **7** shows a possible version of the platform handler. Platform handler **710** is shown. Platform handler **710** includes STP handler **712**, supervisor **714**, and CCM handler **716**. Platform handler **710** transmits and receives ISUP messages to/from the signaling interface (reference numerals **312**, **315**, **320**, and **335**). STP handler **712** would provide the ethernet—TCP/IP interface. STP handler **712** has a process to buffer and dis-assemble the incoming packets to the CCM, and buffer and assemble outgoing packets. STP handler **712** could also check the messages for basic flaws. Any technique for transfer of signaling messages to platform handler **710** is contemplated by the invention.

Supervisor **714** is responsible for managing and monitoring CCM activities. Among these are CCM start-up and shut-down, log-in and log-off of various CCM modules, handling administrative messages (i.e. error, warning, status,

etc.) from the CCM modules, and handling messages from network operations such as queries, configuration instructions, and data updates. The connection to network operations is the man machine interface which allows the CCM to be controlled and monitored by either a remote or a local operator. Supervisor **714** has a process which retrieves configuration data from internal tables to initialize and configure the CCM. The CCM modules also have internal tables which are used in conjunction with this procedure. Supervisor **714** also communicates internally with STP handler **712** and CCM handler **716**.

CCM handler **716** exchanges ISUP information with STP handler **712**. CCM handler **716** also exchanges ISUP messages and CCM supervisory messages with the message handler. The connection between CCM handler **716** and the message handler could be an ethernet LAN transporting these messages encapsulated in TCP/IP packets, but other methods are known. CCM handler **716** would provide the ethernet—TCP/IP interface. CCM handler **716** has a process to buffer and dis-assemble the incoming packets from the message handler, and buffer and assemble outgoing packets to the message handler. CCM handler **716** could also check the messages for basic flaws.

Internally, platform handler **710** is equipped with bidirectional channels which exchange information among STP handler **712**, supervisor **714**, and CCM handler **716**. The channels between STP handler **712**, CCM handler **715**, and supervisor **712** carry supervisory and administrative information. The channel between STP handler **712** and CCM handler **716** carries ISUP message information.

Platform handler **710** accepts, disassembles, and buffers ISUP messages received from the network. It can perform basic checks on the messages before transferring them to the message handler. Should more than one message handler be connected to platform handler **710**, the ISUP messages could be allocated to the message handlers based on the SLS of the particular ISUP message. CCM handler **716** accepts routing instructions from the message handler for routing certain ISUP messages to select processes of the message handler. Platform handler **710** also provides supervision and a man/machine interface for the CCM.

The Message Handler

FIG. **8** depicts a version of the message handler. Message handler **820** is shown and includes call center **821**, origination manager **822**, termination manager **823**, detection point manager **828**, feature manager **824**, auxiliary manager **825**, switching manager **826**, and local resource **827**. A primary function of message handler **820** is to process ISUP messages.

Call center **821** is the process which receives call set-up messages from the platform handler. ISUP call set-up is initiated with the IAM. When call center **821** receives an IAM, it creates an instance of an origination manager process with data defined by the information in the IAM. Origination manager **822** represents any of the origination manager processes spawned by call center **821**. The CCM handler is instructed of the new instance so that subsequent ISUP messages related to that call can be transferred directly to the appropriate instance of origination manager **822** by the platform handler.

Origination manager **822** sets up a memory block called an originating call control block. The call control block provides a repository for information specific to a call. For example, the originating call control block could identify the following: the call control block, the origination manager, the message handler, the originating LEC, the LEC trunk circuit (CIC), the ATM virtual circuit, the ATM virtual path, the caller's number, the dialed number, the translated dialed number, the originating line information, the ANI service class, the selected route, the number of the selected route, the SLS, the OPC, the DPC, the service indicator (SIO), echo cancellation status, reason of release, call status, and pointers to adjacent call control blocks. In addition, the call control block would also contain the various times that signaling messages are received, such the address complete message (ACM), the answer message (ANM), the suspend message (SUS), the resume message (RES), and the release message (REL). Those skilled in the art would be aware of other pertinent data to include.

Origination manager **822** executes call processing in accordance with the Basic Call State Model (BCSM) recommended by the International Telecommunications Union (ITU), but with some notable exceptions. Origination manager **822** processes the IAM through each point in call (PIC) until a detection point (DP) is encountered. When a detection point is encountered, a message is sent to detection point manager **828** and processing is suspended at origination manager **822** until detection point manager **828** responds. An example of a detection point for origination manager **822** would be to authorize an origination attempt.

Detection point manager **828** accepts messages from originating manager **822** caused by a detection point encountered during call processing. Detection point manager **828** will identify whether or not the detection point is armed. An armed detection point has specific criteria which can affect call processing if met. If the detection point is not armed, detection point manager **828** will send a continue signal back to origination manager **822**. A continue message instructs origination manager **822** to continue call processing to the next detection point. If the detection point is armed, detection point manager **828** will take action to see if the detection point criteria are met. If detection point manager **828** requires assistance to process the armed detection point, it will send a message to feature manager **824**.

Feature manager **824** would accept messages from detection point manager **828** and either forward the a message to auxiliary manager **825** or to switching manager **826**. Particular feature messages would be routed to auxiliary manager **825** which will process these call features. These are typically non-IN features, such as echo control or POTS billing. Other feature messages would be routed to switching manager **826**. These are typically IN features. Examples of IN features are 800 number translation or a terminal mobility number translation. Feature manager **824** will pass information back to detection point manager **828** (then to origination manager **822**) when it is received back from auxiliary manager **825** or switching manager **826**.

Switching manager **826** which will determine if the request will be handled by local resource **827** or by the data handler. Local resource **827** will be structured to provide data more efficiently stored at message handler **820**. Examples of such data include: an automatic number identification (ANI) validation table which checks the caller's number, a dialed number translation table to translate POTS numbers into a routing instructions, or N00 translation tables to translate select 800 numbers into routing instructions. Examples of a routing instruction yielded by the tables would be a particular access connection or a virtual connection. An example of data in the data handler would be virtual private network (VPN) routing tables or complex 800 routing plans.

Typically, originating manager **822** will execute through the pertinent points in call to a point indicating that set up is

authorized. At this point, origination manager **822** will instruct call center **821** to create an instance of a termination manager. Termination manager **823** represents any of these termination managers. Origination manager **822** will also transfer IAM information to termination manager **823**. Termination manager **823** sets up a memory block called a terminating call control block. The call control block provides a repository for information specific to a call and is similar in composition to the originating call control block.

Termination manager **823** also operates in accord with the BCSM of the ITU, but also with some exceptions. Termination manager **823** continues processing for the call through its own points in call until detection points are encountered. When a detection point is encountered, a message is sent to detection point manager **828** and processing is suspended at termination manager **823** until detection point manager **828** responds. An example of detection point for termination manager **822** would be to authorize termination which would entail authorizing the call as set-up by origination manager **822**. Messages from termination manager **823** to detection point manager **828** are handled as discussed above for messages from originating manager **822**. When processing by termination manager **823** is complete, it will produce a signaling message to transmit through platform handler **410** to the appropriate multiplexers, and possibly to the users.

Message handler **820** communicates with the data handler using a data transfer protocol. Examples include UDP/IP, or the Intelligent Network Applications Protocol (INAP) which is contained within the component sublayer of Transaction Capabilities Application Part (TCAP).

The Data Handler

FIG. **9** shows a version of the data handler. Data handler **930** is shown. Data handler **930** includes service control center **931**, service selection **932**, service logic center **933**, feature process **934**, service data center **935**, service data manager **936**, echo control **937**, and accounting **938**. Data handler **930** receives service request messages from the message handler. These messages result from an armed detection points triggering the message handler to invoke data handler **930**. The messages also result from features implemented through the auxiliary manager. Service control center **931**, service logic center **933**, and service data center **935** are static processes created at start-up. Service control center **931** creates instances of service selection managers on a call by call basis. Service control center **931** notifies the Switching manager to route subsequent service request messages for that call to the appropriate service selection manager. Service selection manager **932** represents any of the service selection managers created by service control center **931**.

Service selection manager **932** executes the service portion of the call processing. Service selection manager **932** identifies the various services associated with each message and implements the service through messages to service logic center **933**. Service logic center **933** accepts messages from service selection **932** and creates instances of the feature processes required for the identified services. Examples of feature processes are N00, messaging, personal/terminal mobility, and virtual private network (VPN). Feature processes are service logic programs which implement the required services for a call. Feature process **934** represents any of the feature processes created by service logic center **933**. Feature process **934** accesses the network resources and data required to implement the service. This would entail executing service independent blocks (SIBs). A SIB is a set of functions. An example of a function would be to retrieve the called number from a signaling message. SIBs are combined to build a service. An example of a SIB is translating a called number.

Those skilled in the art are familiar with the above services, although they have never been implemented by a system such as the present invention. N00 services are services such as 800, 900, or 500 calling in which the dialed number is used to access call processing and billing logic defined by the subscriber to the service. Messaging entails connecting the caller to a voice messaging service. For example, the receipt of a release message (REL) with a cause of busy could be a trigger recognized by the message handler. In response, the data handler would create an instance of the messaging feature process and determined if a call placed to a particular dialed number would require the voice messaging platform. If so, the CCM would instruct an SSP to connect the caller to the voice message platform. Personal/Terminal mobility includes recognizing that the dialed number has mobility that requires a database look-up to determine the current number. The database is updated when the called party changes locations. VPN is a private dialing plan. It is used for calls from particular dedicated lines, from particular calling numbers (ANIs), or to particular dialed numbers. Calls are routed as defined for the particular plan.

In the execution of the SIB to provide the service, feature process **934** would invoke service data center **935** to create an instance of service data manager **936**. Service data manager **936** accesses the network databases that provide the data required for the service. Access could be facilitated by TCAP messaging to an SCP. Service data manager **936** represents any of the service managers created by service data center **935**. Once the data is retrieved, it is transferred back down to feature process **934** for further service implementation. When the feature processes for a call finish execution, service information is passed back down to the message handler and ultimately to the origination or termination manager for the call.

After a release message on a call, billing requests will be forwarded to accounting **938**. Accounting **938** will use the call control block to create a billing record. The call control block would contain information from the ISUP messages for the call and from CCM processing. From the address complete message (ACM), the call control block would include the routing label, CIC, message type, and cause indicators. From the answer message (ANM), the call control block would include the routing label, CIC, message type, and backward call indicators. From the initial address message (IAM), the call control block would include the routing label, CIC, message type, forward call indicators, user service information, called party number, calling party number, carrier identification, carrier selection information, charge number, generic address, origination line information, original called number, and redirecting number. From the release message (REL), the call control block would include the routing label, CIC, message type, and cause indicators. From the suspend message (SUS) or the pass along message (PAM), the call control block would include the routing label, CIC, and message type. Those skilled in the art are familiar with other pertinent information for a billing record and appreciate that some of this information could be deleted.

For POTS calls, the billing request will come from the origination and termination managers through the auxiliary manager. For IN calls, the request will come from service

selection **932**. Accounting **938** will generate a billing record from the call control blocks. The billing record will be forwarded to a billing system over a billing interface. An example of such an interface is the I.E.E.E. 802.3 FTAM protocol.

At some point during call set-up, the origination manager, termination manager or even the detection point process will check the user service information data and originating line information to assess the need for echo control. If the call is a data call, a message is sent to data handler **930**. Specifically, the message is routed through the auxiliary manager to the echo control manager **937** in data handler **930**. Based on the CIC, echo control manager **937** can select which echo canceller and DS0 circuit needs to be disabled. A message will be generated to that effect and transmitted over a standard data link to the pertinent echo canceller or echo control system. As described above, echo control can be implemented by the multiplexer. Once a release (REL) message is received for the call, the echo canceller is re-enabled. On a typical call, this procedure will occur twice. Once for an echo canceller on the access side, and again for an echo canceller on the terminating side. The CCM that handles the IAM for a particular call segment will control the particular echo cancellers for the segment.

IAM Call Processing

Prior to a description of IAM processing, a brief description of SS7 message is given. SS7 messaging is well known in the art. SS7 ISUP messages contain numerous fields of information. Each message will have a routing label containing a destination point code (DPC), an origination point code (OPC), and a signaling link selection (SLS) which are used primarily for routing the message. Each message contains a circuit identification code (CIC) which identifies the circuit to which the message relates. Each message contains the message type which is used to recognize the message. ISUP messages also contain mandatory parts filled with fixed length data and variable length data, in addition to a part available for optional data. These parts vary from message type to message type depending on the information needed.

The initial address message (IAM) initiates the call and contains call set-up information, such as the dialed number. IAMs are transferred in the calling direction to set up the call. During this process, TCAP messages may be sent to access remote data and processing. When the IAMs have reached the final network element, an address complete message (ACM) is sent in the backward direction to indicate that the required information is available and the called party can be alerted. If the called party answers, an answer message (ANM) is sent in the backward direction indicating that the call/connection will be used. If the calling party hangs up, a release message (REL) is sent to indicate the connection is not being used and can be torn down. If the called party hangs up, a suspend message (SUS) is sent and if the called party reconnects, a resume (RES) message keeps the line open, but if their is no re-connection, a release message (REL) is sent. When the connections are free, release complete messages (RLC) are sent to indicate that the connection can be re-used for another call. Those skilled in the art are aware of other ISUP messages, however, these are the primary ones to be considered. As can be seen, the IAM is the message that sets-up the call.

In the preferred embodiment, call processing deviates from the basic call model recommended by the ITU, although strict adherence to the model could be achieved in other embodiments. FIGS. **10–12** depicts the preferred call processing. Referring first to FIG. **10**, When the IAM for a call is received at **1005**, the call center creates an instance of an origination manager at **1010**.

The origination manager begins call processing by sending an authorize message to the detection point manager. Detection point manager checks IAM information, including the dialed number, the CIC, and the originating line information, to perform service discrimination at **1015**. This is done to determine if the service requested requires validation at **1020**. Current call processing systems and the BCSM of the ITU both validate the call before performing service discrimination. In a significant advance over the prior art, the preferred embodiment deviates from known call processing methods by looking at the IAM information prior to validation to determine if validation is even required. For example, the calling party may not pay the bill for a call. The called party pays the bill on 800 calls and validation can be unnecessary. If validation is not required at **1020**, call processing proceeds directly to B. Advantageously, this avoids unnecessary look-ups in validation tables for a significant percentage of calls.

If validation is required at **1020**, a validation table is checked at **1025**. Validation checks to see if a call should be allowed and focuses on potential billing problems for the call. For example, calls from ANIs that are delinquent on payments pose problems for billing and may not be validated. Validation would entail messaging from the detection point manager through the feature manager and the switching manager to the local resource to access the tables. The table may list authorized ANIs, unauthorized ANIs, or both. If the call is not authorized at **1030**, treatment (i.e. route to an operator or message) is given to the call at **1035**.

If the call is authorized at **1030**, the services identified at **1015** are checked at **1040** to determine if the call can be routed. This would typically occur for POTS calls. If no additional services are required at **1040**, the dialed number is translated into a route instruction at **1045**. The route instruction could be a particular virtual connection and/or access connections. The processing then proceeds to A. If additional services are required at **1040**, processing proceeds to B.

FIG. **11** picks up processing at B after a route has been selected. A termination manager is created at **1105**. The termination manager is responsible for processing in accordance with the terminating BCSM of the ITU. However, in some embodiments, the processing can exhibit some deviation. For example, detection points such as select facility and validate call may be skipped.

The bearer capability is analyzed at **1110** to determine if the call is a data call at **1115**. This analysis could occur elsewhere in the call processing (i.e by the origination manager after the route is selected.) If a data call is found at **1115**, an echo control message is sent to the data handler at **1120**. Echo control instructions are created at **1125**. The echo control instructions identify the connection for the call which requires echo control. The message could be sent to the echo control system over a conventional data link from the CCM to the echo control system. If, the echo control is implemented in the multiplexers, the echo control message could be included with the route instruction message.

If the call is not a data call at **1115** or after echo control processing at **1125**, a signaling message is created at **1135**. The new signaling message identifies the access connections and virtual connection for the call. The new signaling message can also contain echo control instructions. The new signaling message is sent to the platform handler at **1140**.

FIG. **12** picks up the processing at B. At this point, several things are known about the call concerning authorization and service requirements. The call information is then analyzed at **1205** as required to apply services to the call. If the data handler is not required at **1210**, the service is implemented and the route is selected at **1215**. This may occur if a service can be directly implemented by the origination manager or through the local resource. For example, particular 800 translations or dialed number service profiles (i.e call forwarding) can be stored in the local resource. In this case, route selection would be performed by the local resource after the information is analyzed to identify the correct entry to a local resource database. When the local resource is used, the messages must be routed from the detection point processor through the feature manager and switching manager to the local resource.

If the data handler is required for the call at **1210**, a message is sent to the data handler at **1220**. The messaging typically flows from the detection point processor to the feature manager and switching manager to the data handler. Upon receipt of the message at the data handler, the service control center creates an instance of the service selection process at **1225**. The service selection process analyzes the message from the detection point processor and selects the feature processes for the call at **1230**. For example, a call may be placed from a caller in a virtual private network (VPN) to a PCS number. In this case, both a VPN feature process and a PCS feature process would be created.

Each feature process would determine if data was required at **1240**. For example, a personal mobility feature process would need to access a database to locate the called party's current telephone number. If data is required at **1240**, the service data center creates a service data manager at **1245**. The data manager manages the data session and accesses the appropriate database at **1250**. After the data is collected (or none is needed), the service is implemented by the feature process at **1255**. For some features, i.e. 800 service, this may include route selection. The results of the feature process analysis are returned to the origination manager to assimilate. If the feature process does not provide the route, the origination manager must select the route using the local resource or another feature process.

The IAM itself contains numerous fields of information. The following table describes the elements of an IAM with regard to the information content and call processing.

TABLE 1

Initial Address Message

Parameter Field Name	Description
ROUTING LABEL	
Service Indicator	Set at 0101-ISDN user part
Priority	0 or 1 based on destination
Network ID	10 for national network or set based on international trunk group
Destination Point Code	Destination of IAM
Originating Point Code	Origination of IAM
Signaling Link Connection	Link used for messages (same for all messages for the call)
Circuit ID Code	Circuit used for the call between OPC and DPC in the IAM
Message Type	0000 or 0001 for IAM
NATURE OF CONNECTION INDICATORS	
Satellite Indicator	Increment for each satellite used
Continuity Check Indicator	00 -- no check 01 -- set up check and start COT timer 10 -- start timer for COT message.

TABLE 1-continued

Initial Address Message

Parameter Field Name	Description
Echo Suppresser Indicator	Indicates if echo control already implemented or is set if echo control is implemented
FORWARD CALL INDICATORS	
National/International Call Indicator	0 for domestic 1 for international
End to End Method Indicator	Pass any information
Interworking Indicator	Pass any information
IAM Segmentation Indicator	0 for POTS
ISDN User Part Indicator	Pass any information
ISDN Preference Indicator	Pass any information and default to 00
ISDN Access Indicator	Pass any information
SCCP Method Indicator	00
CALLING PARTIES CATEGORY	
Calling Party Category	00000000 for unknown 00001010 for ordinary caller 00001101 for test call
USER SERVICE INFORMATION	
Information Transfer Capability	Pass any information unless destination requires particular settings, but always pass ISDN "unrestricted digital information"
Coding Standard	00
Extension	1
Information Transfer Rate	Pass any information (will be 10000 for POTS)
Transfer Mode	Set at 00 for 64 kbit/sec
Extension	1
User Layer Protocol Identification	Set based on rate adaption, typically 0100010 for user information layer 1
Extension	1 for normal calls 0 for rate adaption
Rate	Nothing for user information layer 1, but 0111 for other rate adaption
Extension	1
CALLED PARTY NUMBER	
Nature of Address Indicator	Identifies the type of call: 0000001 -- original NPA or 950 call 0000011 -- 1+ call 0000100 -- direct dial international call 1110001 -- operator call 1110010 -- operator default 1110011 -- international operator call 1110100 -- long distance operator call 1110101 -- cut through call 1110110 -- 950, hotel/motel, or non equal access call 1110111 -- test call
Odd/Even	number of digits in a called number
Numbering Plan	000 -- default 001 -- for ISDN 101 -- private
Digits Field	number of the called party
ACCESS TRANSPORT	
Access Transport Elements	pass any information
CALLING PARTY NUMBER	
Nature of Address Indicator	Indicates the type of calling party address, unique numbers can be used for billing, but the charge number is used for non-unique numbers: 0000000 -- unknown 0000001 -- unique caller number 0000011 -- unique national number 0000100 -- unique international number 1110001 -- non-unique caller number 1110011 -- non-unique national number 1110100 -- non-unique international number 1110111 -- test call

TABLE 1-continued

Initial Address Message

Parameter Field Name	Description
Odd/Even	Number of digits in the calling number
Screening	Not applicable
Presentation Allowed/Restricted	Pass any information for POTS, but restrict for N00 calls that are not allowed
Numbering Plan	000 -- default 001 -- ISDN 101 -- private
Digits Field	Number of the calling party
CARRIER IDENTIFICATION	
Network Identification Plan	Number of digits in identification code for the requested carrier
Type of Network Identification	Identifies the network numbering plan for the call -- 010 for POTS call from LEC
Digit One	First digit in carrier identification code
Digit Two	Second digit in carrier identification code
Digit Three	Third digit in carrier identification code
Digit Four or Null	Fourth digit in carrier identification code (if there are four digits)
CARRIER SELECTION INFORMATION	
Carrier Selection Indicator	Indicates whether the carrier identification code was presubscribed or input
CHARGE NUMBER	
Nature of Address Indicator	This information may be used for billing. 00000001 -- caller number 00000010 -- no ANI, route to operator 00000011 -- caller's national number 00000101 -- route if 800, or route to operator 0000110 -- no ANI 0000111 -- route if 800 or route to operator
Odd/Even	Number of digits in calling number
Numbering Plan	Pass any information
Digits Field	The number of calling party
GENERIC ADDRESS	
Nature of Address Indicator	Pass any information
Odd/Even	Pass any information
Screening	Pass any information
Presentation Allowed/Restricted	Pass any information
Numbering Plan	Pass any information
Digits Field	Pass any information
ORIGINATING LINE INFORMATION	
Originating Line Information	Identifies particular types of calls, for example: 00000000 -- normal call 00000111 -- call from a restricted phone 00111111 -- call from a cellular roamer
ORIGINAL CALLED NUMBER	
Nature of address Indicator	Pass any information
Odd/Even	Pass any information
Screening	Pass any information
Presentation Allowed/Restricted	Pass any information
Numbering Plan	Pass any information
Digits Field	Pass any information
REDIRECTING NUMBER	
Nature of Address Indicator	Pass any information
Odd/Even	Pass any information
Screening	Pass any information
Presentation Allowed/Restricted	Pass any information
Numbering Plan	Pass any information
Digits Field	Pass any information

TABLE 1-continued

Initial Address Message

Parameter Field Name	Description
REDIRECTION INFORMATION	
Redirection Indicator	Pass any information
Original Redirecting Reason	Pass any information
Redirection Counter	Pass any information
Redirection Reason	Pass any information
SERVICE CODE	
Service Code	Pass any information
TRANSIT NETWORK SELECTION	
Network Identification Plan	Identifies the number of digits in the carrier identification code (3 or 4)
Type of Network Identification	Type of network identification for transit network parameter
Digits 1, 2, 3, 4	Carrier identification code of the international transit carrier
Circuit Code	Indicates how the call was dialed: 0001 -- international call, no operator requested 0010 -- international call, operator requested
HOP COUNTER	
Hop Counter	limits the number of times an IAM may transfer through a signaling point. If the count reaches the limit, release the call

Subsequent ISUP Message Processing

The processing of the IAM is discussed above. Those skilled in the art are will appreciate how other SS7 messages can be incorporated into the processing of the present invention. For example, the time an address complete message (ACM) is received is recorded in the call control block for billing and maintenance. Triggers can also be based on receipt of subsequent messages, such as the ACM. The process for the answer message (ANM) is much the same.

Cut-through is the time point at which the users are able to pass information along the call connection from end to end. Messages from the CCM to the appropriate network elements are required to allow for cut-through of the call. Typically, call connections include both a transmit path from the caller and a receive path to the caller, and cut through is allowed on the receive path after the ACM is received and on the transmit path after the ANM is received.

Upon receipt of a release (REL) message, the CCM will write a time for the message to the call control block and check for triggers upon release (such as call re-originate). Additionally, any disabled echo canceller will be re-enabled, and the call control block will be used to create a billing record. Upon the receipt of a release complete message (RLC), the CCM will transmit messages directing tear down of the call path. It will clear its call specific processes and reuse the call connections for subsequent calls.

Additionally, suspend messages (SUS) and pass along messages (PAM) may be processed by the CCM. A suspend message (SUS) indicates that the called party has disconnected and a REL will follow if the called party does not re-connect with a specified time. A PAM is simply a message between signaling points and can contain a variety of information and be used for a variety of purposes.

The invention allows switching over an ATM fabric on a call by call basis. This allows efficient high capacity virtual connections to be exploited. Advantageously, the invention

does not require signaling capability in an ATM switch. The invention does not require call processing capability in an ATM switch. This enables networks to implement ATM switching without these sophisticated ATM switches that support high volumes of calls. It also avoids the cost of these switches. The invention fully supports voice traffic and non-voice traffic. The invention supports services, such as N00, VPN, personal/terminal mobility, and voice messaging without requiring the service capability in an ATM switch. Relying on ATM cross-connects is advantageous because ATM cross-connects are farther advanced than ATM switches, and the cross-connects require less administrative support.

Those skilled in the art will appreciate that variations from the specific embodiments disclosed above are contemplated by the invention. The invention should not be restricted to the above embodiments, but should be measured by the following claims.

I claim:

1. A method of operating an interworking unit to handle a plurality of calls, the method comprising:

receiving messages into the interworking unit on a call-by-call basis where each one of the messages indicates one of a plurality of synchronous connections and a corresponding one of a plurality of identifiers;

receiving user communications for the calls from the synchronous connections indicated in the messages into the interworking unit;

in response to the messages, converting the user communications from the synchronous connections into asynchronous communications including the corresponding identifiers; and

transferring the asynchronous communications from the interworking unit for subsequent routing based on the identifiers.

2. The method of claim **1** further comprising receiving echo cancellation instructions into the interworking unit on a call-by-call basis and canceling echo from the user communications in response to the echo cancellation instructions.

3. The method of claim **1** further comprising receiving encryption instructions into the interworking unit on a call-by-call basis and encrypting the user communications in response to the encryption instructions.

4. The method of claim **1** further comprising receiving compression instructions into the interworking unit on a call-by-call basis and compressing the user communications in response to the compression instructions.

5. The method of claim **1** further comprising receiving decibel level instructions into the interworking unit on a call-by-call basis and adjusting a decibel level of the user communications in response to the decibel level instructions.

6. The method of claim **1** wherein receiving the user communications from the synchronous connections comprises receiving the user communications in an optical format and converting the user communications into an electrical format.

7. The method of claim **1** wherein receiving the user communications from the synchronous connections comprises receiving the user communications from DS0 connections indicated in the messages.

8. The method of claim **1** wherein the identifiers comprise asynchronous transfer mode connections.

9. An interworking unit to handle a plurality of calls, the interworking unit comprising:

a control interface configured to receive messages on a call-by-call basis where each one of the messages indicates one of a plurality of synchronous connections and a corresponding one of a plurality of identifiers;

a synchronous communication interface configured to receive user communications for the calls from the synchronous connections indicated in the messages;

an asynchronous adaptation layer configured to convert the user communications into asynchronous communications including the corresponding identifiers in response to the messages; and

an asynchronous communication interface configured to transfer the asynchronous communications for subsequent routing based on the identifiers.

10. The interworking unit of claim **9** wherein the control interface is configured to receive echo cancellation instructions on a call-by-call basis, and further comprising a processor configured to cancel echo from the user communications in response to the echo cancellation instructions.

11. The interworking unit of claim **9** wherein the control interface is configured to receive encryption instructions on a call-by-call basis, and further comprising a processor configured to encrypt the user communications in response to the encryption instructions.

12. The interworking unit of claim **9** wherein the control interface is configured to receive compression instructions on a call-by-call basis, and further comprising a processor configured to compress the user communications in response to the compression instructions.

13. The interworking unit of claim **9** wherein the control interface is configured to receive decibel level instructions on a call-by-call basis, and further comprising a processor configured to adjust decibel levels of the user communications in response to the decibel level instructions.

14. The interworking unit of claim **9** wherein the synchronous communication interface is configured to receive the user communications in an optical format and converting the user communications into an electrical format.

15. The interworking unit of claim **9** wherein the synchronous connections comprise DS0 connections.

16. The interworking unit of claim **9** wherein the identifiers comprise asynchronous transfer mode connections.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,343,084 B1
DATED : January 29, 2002
INVENTOR(S) : Joseph Michael Christie

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Title page,
Item [63], **Related U.S. Application Data**, replace "Continuation-in-part of application No. 08/568,551, filed on Dec. 7, 1995, now Pat. No. 5,825,780, which is a continuation of application No. 08/525,897, filed on Sep. 8, 1995, now Pat. No. 5,991,301, which is a continuation of application No. 08/238,605, filed on May 5, 1994, now abandoned."
with -- Continuation of application No. 08/525,897, filed on Sep. 8, 1995, now Pat. No. 5,991,301, which is a continuation-in-part of application No. 08/238,605, filed on May 5, 1994, now abandoned. --

Signed and Sealed this

Twenty-seventh Day of January, 2004

Jon W. Dudas

JON W. DUDAS
Acting Director of the United States Patent and Trademark Office

UNITED STATES PATENT AND TRADEMARK OFFICE

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Signed and Sealed this

Twenty-second Day of February, 2005

Jon W. Dudas

JON W. DUDAS
Director of the United States Patent and Trademark Office

EXHIBIT B

US006633561B2

(12) **United States Patent**
Christie

(10) **Patent No.: US 6,633,561 B2**
(45) **Date of Patent: *Oct. 14, 2003**

(54) **METHOD, SYSTEM AND APPARATUS FOR TELECOMMUNICATIONS CONTROL**

(75) Inventor: **Joseph Michael Christie**, San Bruno, CA (US)

(73) Assignee: **Sprint Communications Company, L.P.**, Overland Park, KS (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **10/002,850**

(22) Filed: **Nov. 14, 2001**

(65) **Prior Publication Data**

US 2002/0039372 A1 Apr. 4, 2002

Related U.S. Application Data

(63) Continuation of application No. 09/082,040, filed on May 20, 1998, which is a continuation of application No. 08/568,551, filed on Dec. 7, 1995, now Pat. No. 5,825,780, which is a continuation of application No. 08/238,605, filed on May 5, 1994, now abandoned.

(51) **Int. Cl.**7 .... **H04L 12/66**

(52) **U.S. Cl.** **370/352**; 370/356; 370/410; 370/522; 379/230

(58) **Field of Search** 370/352–356, 370/401, 410, 389, 422, 426, 351, 360, 522; 379/221.08, 221.09, 221.12, 221.14, 228, 229, 230, 221.1, 219

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,201,889 A	5/1980	Lawrence et al.
4,310,727 A	1/1982	Lawser
4,348,554 A	9/1982	Asmuth
4,453,247 A	6/1984	Suzuki et al.
4,554,659 A	11/1985	Blood et al.

(List continued on next page.)

FOREIGN PATENT DOCUMENTS

AU	B-23853/92	3/1993
CH	685033 A5	2/1995
DE	4225203 A1	12/1992
DE	4327777 C1	2/1995
DE	4332824 C1	3/1995

(List continued on next page.)

OTHER PUBLICATIONS

Helen A. Bauer, John J. Kulzer, Edward G. Sable, "Designing Service–Independent Capabilities for Intelligent Networks," IEEE, Dec. 1988, pp. 31–41.

ITU–T Q.1219, "Intelligent Network User's Guide For Capability Set 1," Apr. 1994.

Thorner, "Intelligent Networks, Capter 2," 1994, Artech House, pp. 11–107.

ITU–T, Recommendation Q.722, "Specifications of Signalling System No. 7, General Function of Telephone Messages and Signals," 1993.

ANSI–TI.111–1992, American National Standard for Telecommunications, "Signaling System No. 7 (SS7)—Message Transfer Part (MTP)," New York, NY.

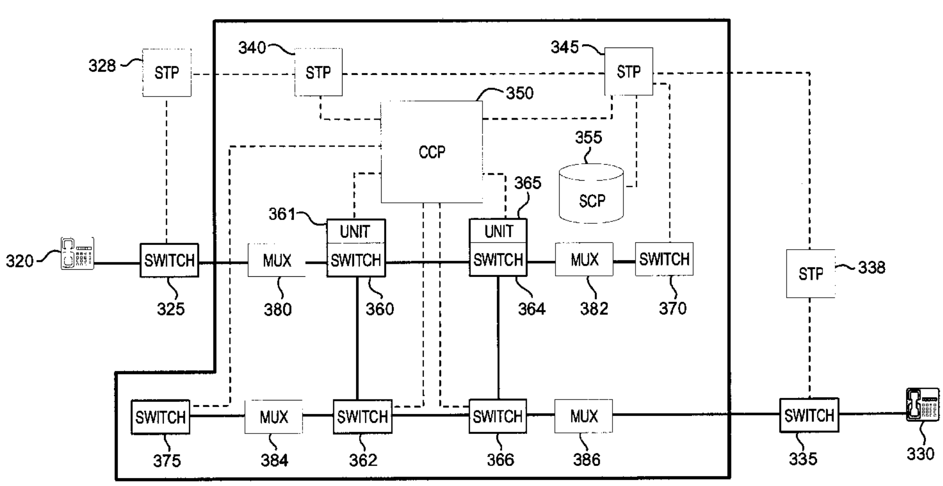
(List continued on next page.)

Primary Examiner—Ajit Patel

(57) **ABSTRACT**

The present invention includes a method, system, and apparatus for providing communication control. The invention includes a method in which signaling is processed externally to a switch before it is applied by the network elements. The processor is able to select network characteristics and signal the network elements based the selections. A network employing the processing method is also included, as well as a signaling system that employs the processing method.

38 Claims, 8 Drawing Sheets



U.S. PATENT DOCUMENTS

4,565,903 A 1/1986 Riley
4,683,563 A 7/1987 Rouse et al.
4,720,850 A 1/1988 Oberlander
4,736,364 A 4/1988 Basso et al.
4,748,658 A 5/1988 Gopal et al.
4,763,317 A 8/1988 Lehman
4,823,338 A 4/1989 Chan et al.
4,853,955 A 8/1989 Thorn et al.
4,896,319 A 1/1990 Lidinsky et al.
4,916,690 A 4/1990 Barri
4,926,416 A 5/1990 Weik
4,985,889 A 1/1991 Frankish et al.
4,991,204 A 2/1991 Yamamoto et al.
4,993,014 A 2/1991 Gordon
5,003,584 A 3/1991 Benyacar et al.
5,018,191 A 5/1991 Catron et al.
5,036,318 A 7/1991 Bachhuber et al.
5,048,081 A * 9/1991 Gavaras et al. 379/230
5,051,983 A 9/1991 Kammerl
5,058,104 A 10/1991 Yonehara et al.
5,067,123 A 11/1991 Hyodo et al.
5,073,890 A 12/1991 Danielsen
5,084,867 A 1/1992 Tachibana et al.
5,086,461 A 2/1992 Thorn et al.
5,089,954 A 2/1992 Rago
5,091,903 A 2/1992 Schrodi
5,101,404 A 3/1992 Kunimoto et al.
5,115,427 A 5/1992 Johnson, Jr. et al.
5,115,431 A 5/1992 Williams et al.
5,163,057 A 11/1992 Grupp
5,168,492 A 12/1992 Beshai et al.
5,179,556 A 1/1993 Turner
5,182,550 A 1/1993 Masuda et al.
5,185,743 A 2/1993 Murayama et al.
5,193,110 A 3/1993 Jones et al.
5,204,857 A 4/1993 Obara
5,216,669 A 6/1993 Hofstetter et al.
5,218,602 A 6/1993 Grant et al.
5,231,631 A 7/1993 Buhrke et al.
5,231,633 A 7/1993 Hluchyj et al.
5,233,607 A 8/1993 Barwig et al.
5,239,539 A 8/1993 Uchida et al.
5,239,542 A 8/1993 Breidenstein et al.
5,249,178 A 9/1993 Kurano et al.
5,251,255 A 10/1993 Epley
5,253,247 A 10/1993 Hirose et al.
5,255,266 A 10/1993 Watanabe et al.
5,258,752 A 11/1993 Fukaya et al.
5,258,979 A 11/1993 Oomuro et al.
5,268,895 A 12/1993 Topper
5,271,010 A 12/1993 Miyake et al.
5,274,680 A 12/1993 Sorton et al.
5,278,889 A 1/1994 Papanicolaou et al.
5,282,244 A 1/1994 Fuller et al.
5,285,441 A 2/1994 Bansal et al.
5,289,536 A 2/1994 Hokari
5,291,479 A 3/1994 Vaziri et al.
5,291,492 A 3/1994 Andrews et al.
5,311,509 A 5/1994 Heddes et al.
5,317,562 A 5/1994 Nardin et al.
5,323,389 A 6/1994 Bitz et al.
5,327,421 A 7/1994 Hiller et al.
5,327,433 A 7/1994 Hall
5,329,308 A 7/1994 Binns et al.
5,339,318 A 8/1994 Tanaka et al.
5,345,443 A 9/1994 D'Ambrogio et al.
5,345,445 A 9/1994 Hiller et al.
5,345,446 A 9/1994 Hiller et al.
5,357,510 A 10/1994 Norizuki et al.
5,363,433 A 11/1994 Isono
5,365,524 A 11/1994 Hiller et al.
5,367,566 A 11/1994 Moe et al.
5,373,504 A 12/1994 Tanaka et al.
5,375,124 A 12/1994 D'Ambrogio et al.
5,377,186 A 12/1994 Wegner et al.
5,384,771 A 1/1995 Isidoro et al.
5,384,840 A 1/1995 Blatchford et al.
5,392,402 A 2/1995 Robrock, II
5,394,393 A 2/1995 Brisson et al.
5,394,398 A 2/1995 Rau
5,414,701 A 5/1995 Shtayer et al.
5,418,783 A 5/1995 Yamaki et al.
5,420,857 A 5/1995 Jurkevich
5,420,858 A 5/1995 Marshall et al.
5,420,916 A 5/1995 Sekiguchi
5,422,882 A 6/1995 Hiller et al.
5,425,090 A 6/1995 Orriss
5,426,636 A 6/1995 Hiller et al.
5,428,607 A 6/1995 Hiller et al.
5,428,609 A 6/1995 Eng et al.
5,434,852 A 7/1995 La Porta et al.
5,434,981 A 7/1995 Lenihan et al.
5,440,563 A 8/1995 Isidoro et al.
5,440,626 A 8/1995 Boyle et al.
5,444,713 A 8/1995 Backaus et al.
5,446,738 A 8/1995 Kim et al.
5,448,569 A 9/1995 Huang et al.
5,452,296 A 9/1995 Shimizu
5,452,297 A 9/1995 Hiller et al.
5,453,981 A 9/1995 Katsube et al.
5,454,034 A 9/1995 Martin
5,457,684 A 10/1995 Bharucha et al.
5,459,721 A * 10/1995 Yoshida 370/389
5,463,620 A 10/1995 Sriram
5,463,621 A 10/1995 Suzuki
5,469,501 A 11/1995 Otsuka
5,473,677 A 12/1995 D'Amato et al.
5,473,679 A 12/1995 La Porta et al.
5,477,537 A 12/1995 Dankert et al.
5,479,401 A 12/1995 Bitz et al.
5,479,402 A 12/1995 Hata et al.
5,479,495 A 12/1995 Blumhardt
5,483,527 A 1/1996 Doshi et al.
5,485,455 A 1/1996 Dobbins et al.
5,495,484 A 2/1996 Self et al.
5,504,742 A 4/1996 Kakuma et al.
5,506,844 A 4/1996 Rao
5,509,010 A * 4/1996 La Porta et al. 370/410
5,509,123 A 4/1996 Dobbins et al.
5,513,178 A 4/1996 Tanaka
5,513,180 A 4/1996 Miyake et al.
5,519,707 A 5/1996 Subramanian et al.
5,521,910 A 5/1996 Matthews
5,522,042 A 5/1996 Fee et al.
5,526,359 A 6/1996 Read et al.
5,530,698 A 6/1996 Kozaki et al.
5,533,106 A 7/1996 Blumhardt
5,539,815 A 7/1996 Samba
5,539,816 A 7/1996 Pinard et al.
5,539,884 A 7/1996 Robrock, II
5,541,918 A 7/1996 Ganmukhi et al.
5,541,926 A 7/1996 Saito et al.
5,544,152 A 8/1996 Obermanns et al.
5,544,161 A 8/1996 Bigham et al.
5,548,580 A 8/1996 Buckland
5,550,819 A 8/1996 Duault
5,550,834 A 8/1996 D'Ambrogio et al.
5,550,914 A 8/1996 Clarke et al.
5,563,939 A 10/1996 La Porta et al.
5,566,173 A 10/1996 Steinbrecher
5,568,475 A 10/1996 Doshi et al.

5,570,368	A		10/1996	Murakami et al.	
5,577,039	A		11/1996	Won et al.	
5,579,311	A		11/1996	Chopping et al.	
5,583,849	A		12/1996	Ziemann et al.	
5,586,177	A		12/1996	Farris et al.	
5,587,999	A		12/1996	Endo	
5,592,477	A		1/1997	Farris et al.	
5,600,640	A		2/1997	Blair et al.	
5,600,643	A		2/1997	Robrock, II	
5,627,836	A		5/1997	Conoscenti et al.	
5,629,930	A		5/1997	Beshai et al.	
5,635,980	A		6/1997	Lin et al.	
5,636,210	A		6/1997	Agrawal et al.	
5,640,446	A		6/1997	Everett et al.	
5,661,725	A		8/1997	Buck et al.	
5,673,262	A		9/1997	Shimizu	
5,680,390	A		10/1997	Robrock, II	
5,703,876	A		12/1997	Christie	
5,708,702	A		1/1998	De Paul et al.	
5,710,769	A		1/1998	Anderson et al.	
5,719,863	A		2/1998	Hummel	
5,765,108	A	*	6/1998	Martin et al.	455/422
5,991,301	A		11/1999	Christie	
6,016,343	A		1/2000	Hogan et al.	
6,175,574	B1	*	1/2001	Lewis	370/522

FOREIGN PATENT DOCUMENTS

DE	4447230	A1	7/1995
DE	19534754	C1	9/1995
EP	0435448	A2	11/1990
EP	0403414	A2	12/1990
EP	0454332	A3	4/1991
EP	0426911	A1	5/1991
EP	0442754	A2	8/1991
EP	0460843	A2	12/1991
EP	0466078	A2	1/1992
EP	0482773	A1	4/1992
EP	91311342.9		7/1992
EP	0559979	A2	8/1992
EP	0539016	A2	4/1993
EP	0549016	A1	6/1993
EP	0582418	A2	2/1994
EP	0592152	A2	4/1994
EP	592153	A2	4/1994
EP	592154	A2	4/1994
EP	0608584	A1	8/1994
EP	0650281	A1	4/1995
FR	2616 025	A1	12/1988
FR	2714559	A1	6/1995
JP	870284896		5/1989
JP	07050057		9/1996
SU	1515172	A1	10/1989
SU	1806444	A3	3/1993
WO	WO 92/14321		8/1992
WO	WO 93/18598		9/1993
WO	WO 94/05121		3/1994
WO	WO 94/06251		3/1994
WO	WO 95/04436		2/1995
WO	WO 95/08881		3/1995

OTHER PUBLICATIONS

ANSI–TI.112–1992, American National Standard for Telecommunications, "Signaling System No. 7 (SS7)—Signaling Connection Control Part (SCCP)," New York, NY.

ANSI–TI.113–1992, American National Standard for Telecommunications, "Signaling System No. 7 (SS7)—Integrated Services Digital Network (ISDN) User Part," New York, NY.

ANSI–TI.113a–1993, American National Standard for Telecommunications, "Signaling System No. 7 (SS7)—Integrated Services Digital Network (ISDN) User Part (Nxdso Multi–Rate Connection)," Washington, D.C.

ANSI–TI.113–1995, American National Standard for Telecommunications, "Signaling System No. 7 (SS7)—Integrated Services Digital Network (ISDN) User Part," New York, NY.

McDysan, David E. And Spohn, Darren L., ATM Theory And Application, 1994, p. 256: 9.3.1; ATM Layer VPI/VCI Level Addressing.

Choi, Requirements For ATM Trunking, ATM Forum Technical Committee 95–1401, Oct. 2–6, 1995.

Stodola "Circuit Emulation Services Version 2 Baseline," ATM Forum Technical Committee 95–1504, Dec. 11–15, 1995.

Okutani et al., "VTOA: Reference Configuration—ATM Trunking for Narrowband Services," ATM Forum Technical Committee 95–1364, Oct. 2–6, 1995.

Ohta, S., et al., A Dynamically Controllable ATM Transport Network Based On The Virtual Path Concept, pp. 1271–1276, Communications For The Information Age, Globecom '88, Conference Record, vol. III, Nov. 28–Dec. 1, 1988.

Duault, Proposal For ATM Trunking Options, ATM Forum Technical Committee, 95–1230, Oct. 2–6, 1995.

Schink, "CES As A Flexible Trunking Method", ATM Forum Technical Committee 95–1157, Oct. 2–6, 1995.

Caves, Proposed modifications to the baseline text (95–0446R2) of the "VTOA—ATM Trunking For Narrowband Services Specification", ATM Forum Technical Committee 95–1134, Oct. 2–6, 1995.

Kumar, "SAA/VTOA Legacy Voice Service At A Native ATM Terminal", ATM Forum Technical Committee 95–0917R1, Oct. 2–6, 1995.

Duault, "Baseline Text For Voice And Telephony Over ATM–ATM Trunking For Narrowband Services", ATM Forum Forum Technical Committee 95–0446R3, Oct. 2–6, 1995.

Chiang, "Proposed Changes To Proxy Signaling Capability", ATM Forum Signaling Working Group 95–0046, Feb. 6–10, 1995.

Amin–Salehi, "Third Party Call Setup For A Video–On–Demand Connection Establishment", ATM Forum Technical Committee 95–0022, Feb. 5–8, 1995.

"ATM At A Glance," Transmission Technologies Access Guide, pp. 40–42, 1993.

Andrews, F., "Switching In A Competitive Market," IEEE Communications Magazine, Jan. 1991.

Atoui, M., "Virtual Private Network Call Processing In The Intelligent Network," pp. 561–565, Chicago, IL, International Conference on Communications, vol. II., 1992.

Barr, W.J., et al., The Tina Initiative, IEEE Communications Magazine, vol. 31, No. 3, New York (US), pp. 70–76, Mar. 1993.

Bosco, P., et al., "A Laboratory For AIN Service Design And Validation," pp. 566–571, Chicago, International Conference on Communications, vol. II., Jun. 14, 1992.

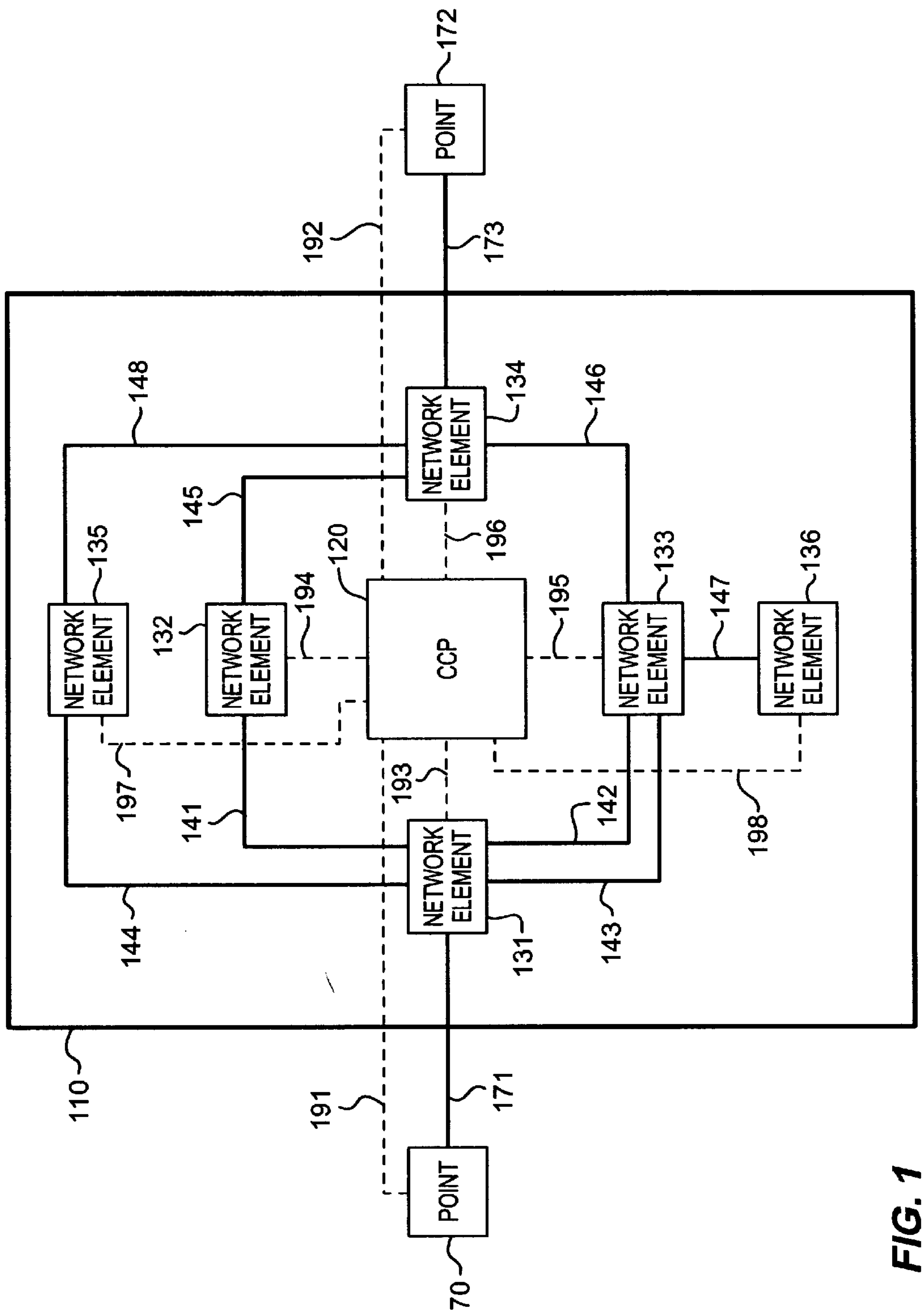
Chen, S., et al., Intelligent Networking For The Global Marketplace, IEEE Communications Magazine, vol. 31, No. 3, Mar. 1993, New York (US), pp. 86–92.

Cooper, C., et al., "Toward A Broadband Congestion Control Strategy," IEEE Network, The Magazine of Computer Communications, May 1990.

Fujioka, M., et al., "Universal Service Creation And Provision Environment For Intelligent Network," IEEE Communications Magazine, Jan. 1991.
Garrahan, J.J., et al., "Intelligent Network Overview," pp. 30–36, IEEE Communications Magazine, Mar. 1993.
Gilmour, J., et al., Intelligent Network/2: The Architecture—The Technical Challenges—The Opportunities, IEEE Communications Magazine, vol. 26, No. 12, Dec. 1988, New York (US) pp. 8–11 and 63.
Homa, J., et al., "Intelligent Network Requirements For Personal Communications Services," pp. 70–76, IEEE Communications Magazine, Feb. 1992.
Johnson, M. A., et al., "New Service Testing Functions For Advanced Intelligent Networks," pp. 709–720, 1992, Memphis, TN, IEEE 1992 Network Operations and Management Symposium, vol. III, Apr. 6, 1992.
Minzer, Steven, A Signaling Protocol For Complex Multimedia Services, pp. 1383–1394, IEEE Journal of Selected Areas in Communications vol. 9, No. 9 (ISSN 0733–8716).
Pinkham, G., et al. The Ericsson Approach To Intelligent Networks, pp. 320–324, Hollywood, FL, IEEE Global Telecommunications Conference & Exhibition, Session 10, paragraph 4, vol. I, 1988.
Weissner, F. J., et al., The Intelligent Network And Forward–Looking Technology, IEEE Communications Magazine, vol. 26, No. 12, Dec. 1988, New York (US), pp. 64–69, Dec., 1988.
Woodworth, Clark B., et al., "A Flexible Broadband Packet Switch For A Multimedia Integrated Network," pp. 3.2.1–3.2.8, International Conference on Communications, Denver, ICC–91, Jun. 1991.
Yeh, S.Y., et al., The Evolving Intelligent Network Architecture, pp. 835–839, 1990, Hong Kong, IEEE Conference on Computer and Communications Systems.
"IN/B–ISDN Signaling Three Ways Of Integration," Study Group 11, Geneva, ITU—Telecommunications Standardization Sector, Nov. 29–Dec. 17, 1993.
"Interworking B–ISUP and Q.93B for DDI, MSN, TP and SUB," Study Group 11, Geneva, ITU—Telecommunication Standardization Sector, Nov. 29–Dec. 17, 1993.
"Q.2931, Clause 4—Information Elements," Geneva, ITU–Telecommunications Standardization Sector, Nov. 29–Dec. 17, 1993.
"Section 5 Of Q.93B," Study Group 11, Geneva, ITU—Telecommunications Standardization Sector, Nov. 29–Dec. 17, 1993.
"Chapter 6 Of Recommendation Q.93B," Study Group 11, Geneva, ITU—Telecommunication Standardization Sector, Nov. 29–Dec. 17, 1993.
"Clauses 7 And 8 Of Q.2931," Study Group 11, ITU–Telecommunications Standardization Sector, Dec. 1993.
"Revised Q.2931 User Side SDL Diagrams," Study Group 11, ITU–Telecommunications Standardization Sector, Nov. 29–Dec. 17, 1993.
ITU—Telecommunication Standardization Sector, "Annexes B, C, D, F, H and I OF Q.2931," Study Group 11, ITU—Telecommunication Standardization Sector, Nov. 29–Dec. 17, 1993.
"Annex E Of Recommendation Q.93B," Study Group 11, ITU–Telecommunications Standardization Sector, Nov. 29–Dec. 17, 1993.
"Annex J Of Q.2931," Study Group 111, ITU—Telecommunication Standardization Sector, Dec. 1993.
"Appendix 1/Q2931: Guidelines For The Use Of Instruction Indicators," Study Group 11, ITU—Telecommunication Standardization Sector, Nov. 29–Dec. 17, 1993.
"Draft Text For Q.2931: Appendix II (Information Items Required For Connection Establishment And Routing In B–ISDN)," Study Group 11 ITU—Telecommunications Standardization Sector.
General Recommendations On Telephone Switching And Signaling Intelligent Network—Intelligent Network Distributed Functional Plane Architecture, Q.1204, ITU–T—Mar. 1993.
General Recommendations On Telephone Switching And Signaling Intelligent Network–Intelligent Network Physical Plane Architecture Q.1205, ITU–T Recommendation, Telecommunication Standardization Sector of ITU.
"General Recommendations On Telephone Switching And Signaling—Intelligent Network/Distributed Functional Plane For Intelligent Network CS–1," ITU–T Recommendations Q.1214, ITU—Telecommunication Standardization Sector.
"Revised Draft Of Q.2650 (DSS2/B–ISUP Interworking Recommendation)," Study Group 11, Geneva, ITU—Telecommunication Standardization Sector, Nov. 29–Dec. 17, 1993.
"Draft Broadband/Narrowband NNI Interworking Recommendation," Study Group 111, Geneva, ITU—Telecommunication Standardization Sector, Dec. 1993.
"Draft Recommendations Q.2761," Study Group 11, Geneva, ITU—Telecommunications Standardization Sector, Nov. 29–Dec. 17, 1993.
"Draft Recommendations Q.2762," Study Group 11, Geneva, ITU—Telecommunication Standardization Sector, Nov. 29–Dec. 17, 1993.
"Clean Final Draft Text For B–ISUP Formats And Codes (Q.2763) In ASN.1," Study Group 11, Geneva, ITU—Telecommunication Standardization Sector, Nov. 29–Dec. 17, 1993.
"Updated Draft Of Q.2764 (BQ.764)," Study Group 11, Geneva, ITU—Telecommunication Standardization Sector, Nov. 29–Dec. 17, 1993.
"Draft Recommendation Q.2650," Study Group 11, Geneva, ITU—Telecommunication Standardization Sector, Nov. 29–Dec. 17, 1993.
"Revised Draft Of Q.2650 (DSS/B–ISUP Interworking Recommendation)," Study Group 11, Geneva, ITU—Telecommunication Standardization Sector, Nov. 29–Dec. 17, 1993.
"Draft Text For Q.2931 (CH. 1,2 And 3)," Study Group 11, Geneva, ITU—Telecommunication Standardization Sector, Dec. 1993.
"Rec. Q.2931, Annex G—Status Monitoring Of Spcs," Study Group 11, ITU—Telecommunication Standardization Sector, Nov. 29–Dec. 17, 1993.
"Q.2931 Overview," Geneva, ITU—Telecommunication Standardization Sector, Nov. 29–Dec. 17, 1993.
"Final B–ISUP SDLS," Study Group 11, Geneva, ITU—Telecommunication Standardization Sector, Nov. 29–Dec. 17, 1993.
"Revised Q.2931 Network Side SDL Diagrams," Study Group 11, ITU —Telecommunication Standardization Sector, Nov. 29–Dec. 17, 1993.
"Revision Of Recommendation Of Q.850," Geneva, ITU—T SG 11 WP 2, Dec. 2–15, 1993.

"Final Draft Text For Broadband Capability Set 2 Signaling Requirements," Study Group 11 Attachment "D" Special Drafting Meeting, pp. 1–127, Torino, Italy, ITU–T Telecommunications Standardization Sector, Sep. 13–22, 1993.
ITU Draft Recommendation I.363.1, B–ISDN ATM Adaptation Layer (AAL) Specification, Types 1 & 2, Jul. 21, 1995.
Rec. I. 312, "ISDN—Principles Of Intelligent Network Architecture." ITU—Telecommunication Standardization Sector, Oct. 1992.
Rec. Q. 1201, "Overall Network Aspects And Functions, ISDN User–Network Interfaces—Principles Of Intelligent Network Architecture." ITU—Telecommunication Standardization Sector, Oct. 1992.
Rec. Q.1200. "General Recommendations On Telephone Switching And Signaling–Intelligent Network—Q Series Intelligent Network Recommendations Structure." ITU—Telecommunication Standardization Sector, Sep. 1997.
Yoshikai, N. et al., "General Arrangements for Interworking Between B–ISDN and 64kbit/s Based ISDN (Draft Recommendation I.580), Study Group 13," ITU–T Telecommunication Standardization Sector, pp. 1–51, (Mar. 7, 1994).
Rec. Q. 1218, "General Recommendations On Telephone Switching And Signaling–Intelligent Network—Interface Recommendation For Intelligent Network CS–1." ITU—Telecommunication Standardization Sector, Oct. 1995.
"Editorial Modifications For Draft New ITU–T Recommendation 1.731", Study Group 15, Temporary Document 70 (PLE/15), ITUT, 13–24 Nov. May 1995.
"Draft Revised Recommendation 1.580" Study Group 13, Temporary Document 62(P), ITUT, Jul. 10–12, 1995.
"Draft 1.732", Study Group 15, Temporary Document 40 (PLE/15), ITUT, Nov. May 13–24, 1995.
1.751 Asynchronous Transfer Mode (ATM) Management View Of The Network Element View, Study Group 15, Temporary Document 32 (PLE/15), ITUT, Nov. May 13–24, 1995.
"Report Of The Meeting Of SWP 13/1–4", Study Group 13, Temporary Document 46 (13/1), ITUT, Mar. 1994.
"Annexes B, C, D, F, H and I Of Q.2931", Study Group 11, Temporary Document 2/II–27 C, ITU—Telecommunication Standardization Sector, Nov. 29–Dec. 17, 1993.
"ISCP Baseline Document (VER 3.1)," ITU Telecommunication Standardization Sector, Centre Studi E Laboratori Telecommunicazoni S.p.A., Geneva, Paglialunga, A., 1993.
Batten, A., "Personal Communications Services And The Intelligent Network," British Telecommunications Engineering, vol. 9, Aug. 1990.
Beckman, Richard T. and Matthews, Joseph R., "Proposal For A Physical Architecture Based On The Harmonized Functiona Architecture," Committee T1 Contribution T1S1.5/95–027, Bellcore,. Feb. 20, 1995.
Buhrke, Proposed Unified Functional Model, T1S1.5/95–036, Feb. 1995.
Faynberg, I., et al., "The Support Of Network Interworking And Distributed Context Switching In The In Service Data Function Model," pp. 11–16, 2nd Colloque International, ICIN 92, Mar. 1992.
Fukuzawa, M., et al., "Intelligent Network Call Model For Broadband ISDN," pp. 30.6.1–30.6.5, Fujitsu Laboratories Ltd., Japan.
Jordan, Bell Operating Company Intelligent Voice Networks And Services, Bell Communications Research, (New Jersey), pp. 100–113.
Miller, P., "Intelligent Network/2: A Flexible Framework For Exchange Services," Bell Communications Research Exchange, vol. 3, Issue 3, May/Jun. 1987.
Minoli, Daniel/DVI Communications, Inc./Stevens Institute of Technology and Dobrowski, George/Bell Communications Research (Bellcore), Principles Of Signaling For Cell Relay And Frame Relay © pp. 1–2, 5–6 and 229, 1994.
Russo, E.G., et al., "Intelligent Network Platforms In The U.S.," pp. 26–43, AT&T Technical Journal, 1991.
Sprague, David, "MTP Level–3 Gateway Stp Release 3.2.0," pp. 1–48, Tekelec, Aug. 4, 1995.
Van den Broek, W., et al., "Race 2066—Functional Models Of UMTS And Integration Into The Future Networks," pp. 165–172, Electronics & Communications Engineering Journal, Jun. 1993.
"Network Signaling," Telephony, TCX12004, University of Excellence, pp. 5.8–5.17, Oct. 21, 1991.
"A Technical Report On Speech Packetization," Document T1A1/94—Prepared by T1A1.7, Working Group on Specialized Signal Processing.
McKinney, Scott, "ATM for Narrowband Services" IEEE Communications Magazine, Apr., 1994, New York, US, pp. 64–72.
Palmer, Rob, "An Experimental ATM Network for B–ISDN Research," IEEE 1992, Melbourne, Australia.
ITU–T H.323, "Line Transmission of Non–Telephone Signals—Visual Telephone Systems and Equipment for Local Area Networks Which Provide a Non–Guarenteed Quality of Service." May 23, 1996.
Dingle, Barry T., ISDN Signaling Control Part (ISCP) Telecom Australia Research Laboratories, Australian Broadband Switching and Services Symposium, 1992.
Sutherland, S.L., "Broadband ISDN Interworking" Australian Broadband Switching and Services Symposium, Melbourne, Jul. 1992.
Palmer, Rob, "An Experimental ATM Network Featuring De–Coupled Modular Control," Telecom Australia Research Laboratories (Victoria), pp. 118–122 (Nov., 1992).

* cited by examiner



POINT
172
192
173
148
NETWORK ELEMENT
134
146
145
196
120
135
NETWORK ELEMENT
132
NETWORK ELEMENT
194
CCP
195
133
NETWORK ELEMENT
147
136
NETWORK ELEMENT
197
193
198
141
142
NETWORK ELEMENT
144
131
143
110
191
171
POINT
170

FIG. 1

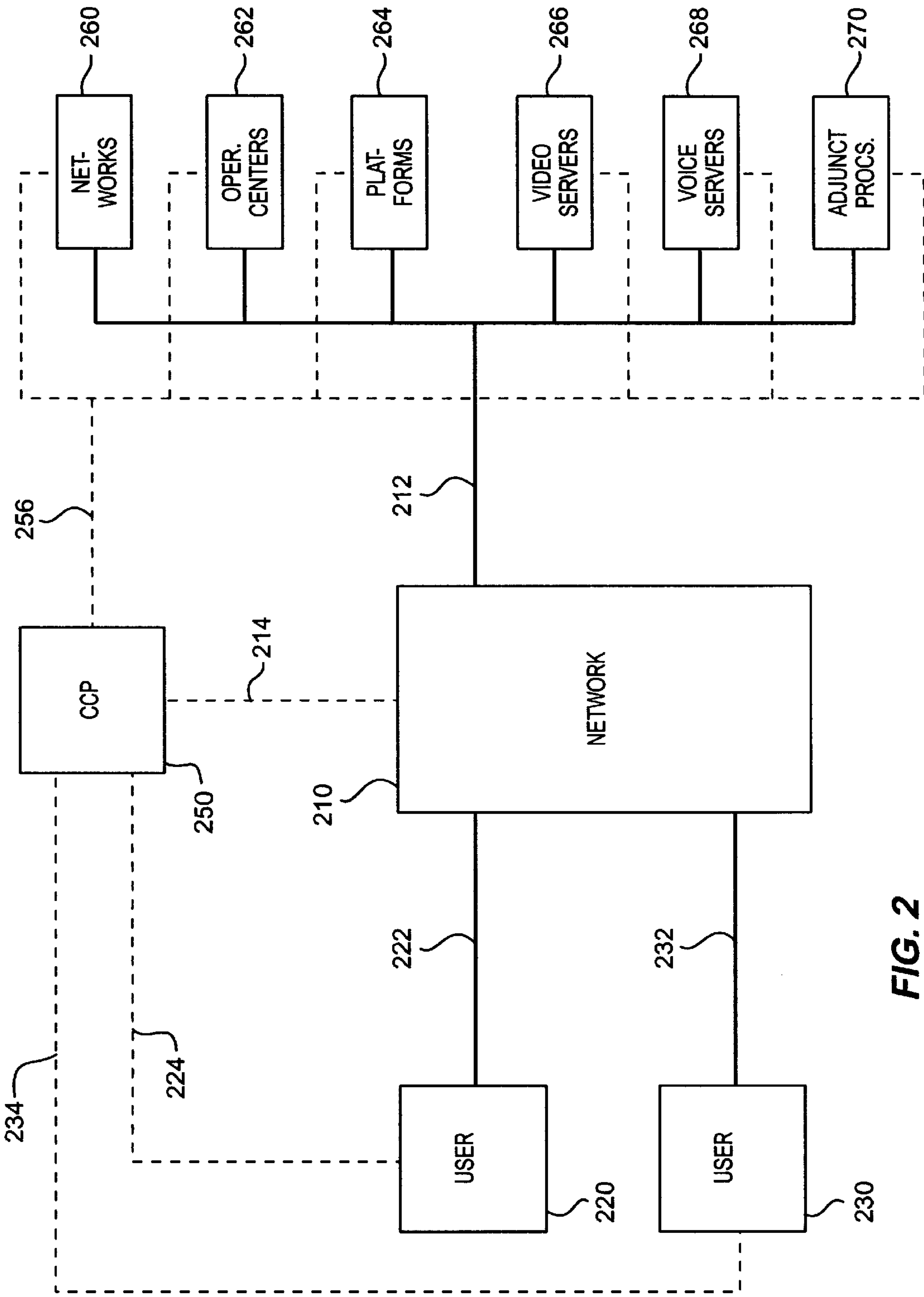

NET-WORKS
260
OPER. CENTERS
262
PLAT-FORMS
264
VIDEO SERVERS
266
VOICE SERVERS
268
ADJUNCT PROCS.
270
256
212
CCP
214
250
NETWORK
210
222
232
224
234
USER
220
USER
230

FIG. 2

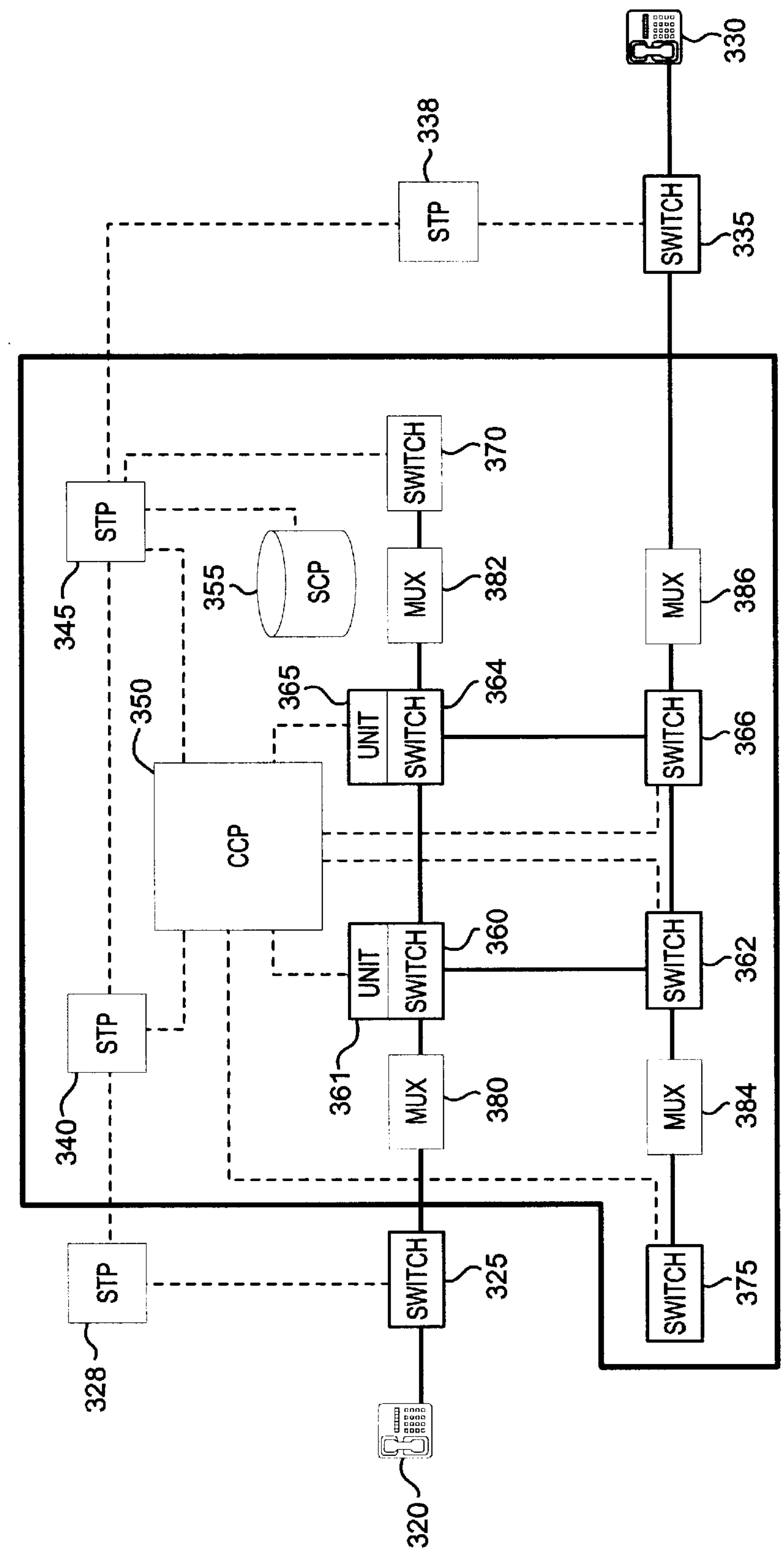

330
338
STP
SWITCH
335
SWITCH
370
STP
345
SCP
355
MUX
382
MUX
386
350
365
UNIT
SWITCH
364
SWITCH
366
CCP
UNIT
SWITCH
360
SWITCH
362
STP
340
361
MUX
380
MUX
384
STP
328
SWITCH
325
SWITCH
375
320

FIG. 3

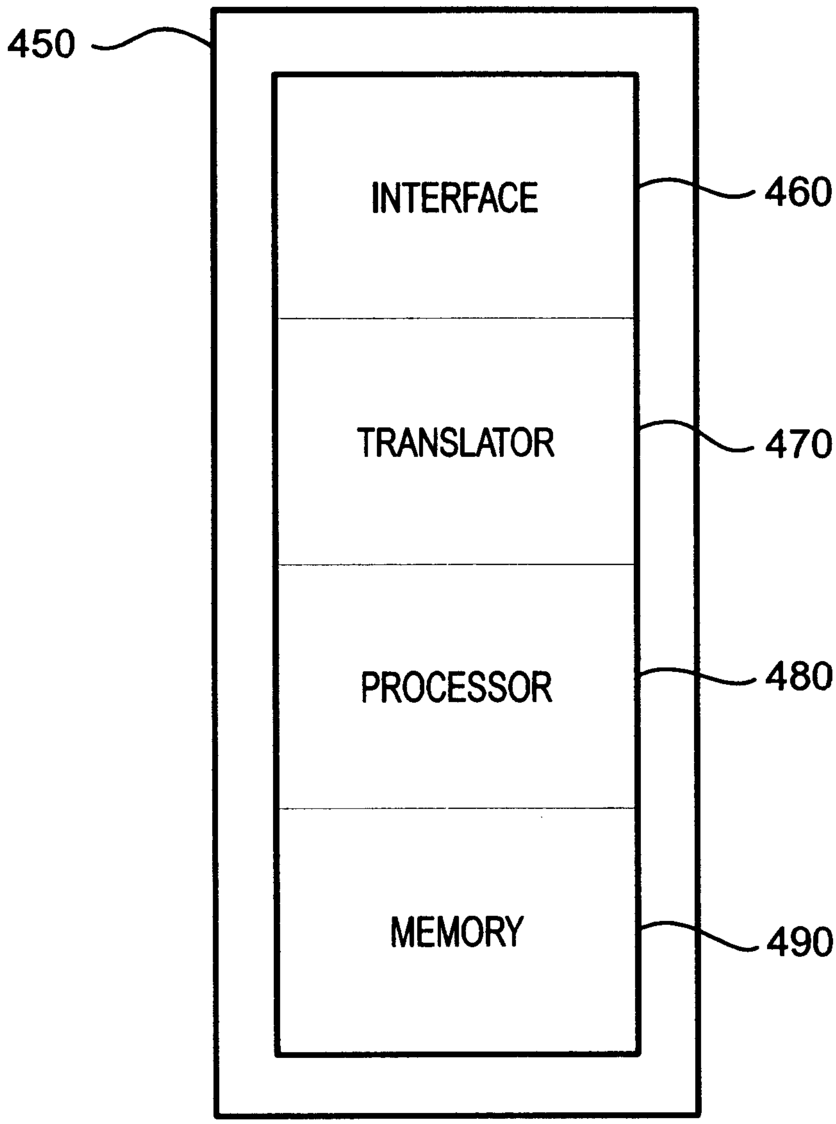


FIG. 4

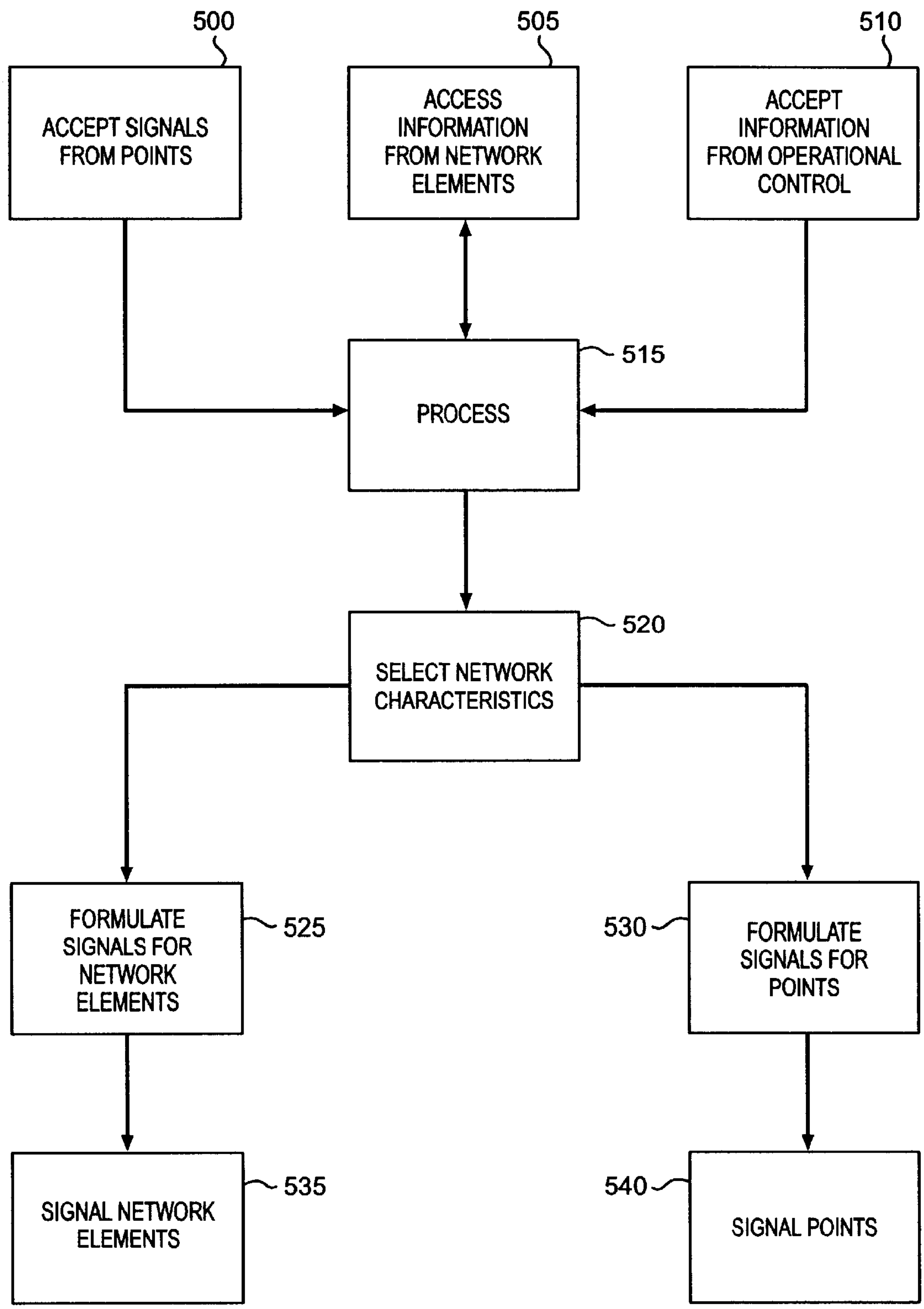

500
ACCEPT SIGNALS FROM POINTS
505
ACCESS INFORMATION FROM NETWORK ELEMENTS
510
ACCEPT INFORMATION FROM OPERATIONAL CONTROL
515
PROCESS
520
SELECT NETWORK CHARACTERISTICS
525
FORMULATE SIGNALS FOR NETWORK ELEMENTS
530
FORMULATE SIGNALS FOR POINTS
535
SIGNAL NETWORK ELEMENTS
540
SIGNAL POINTS

FIG. 5

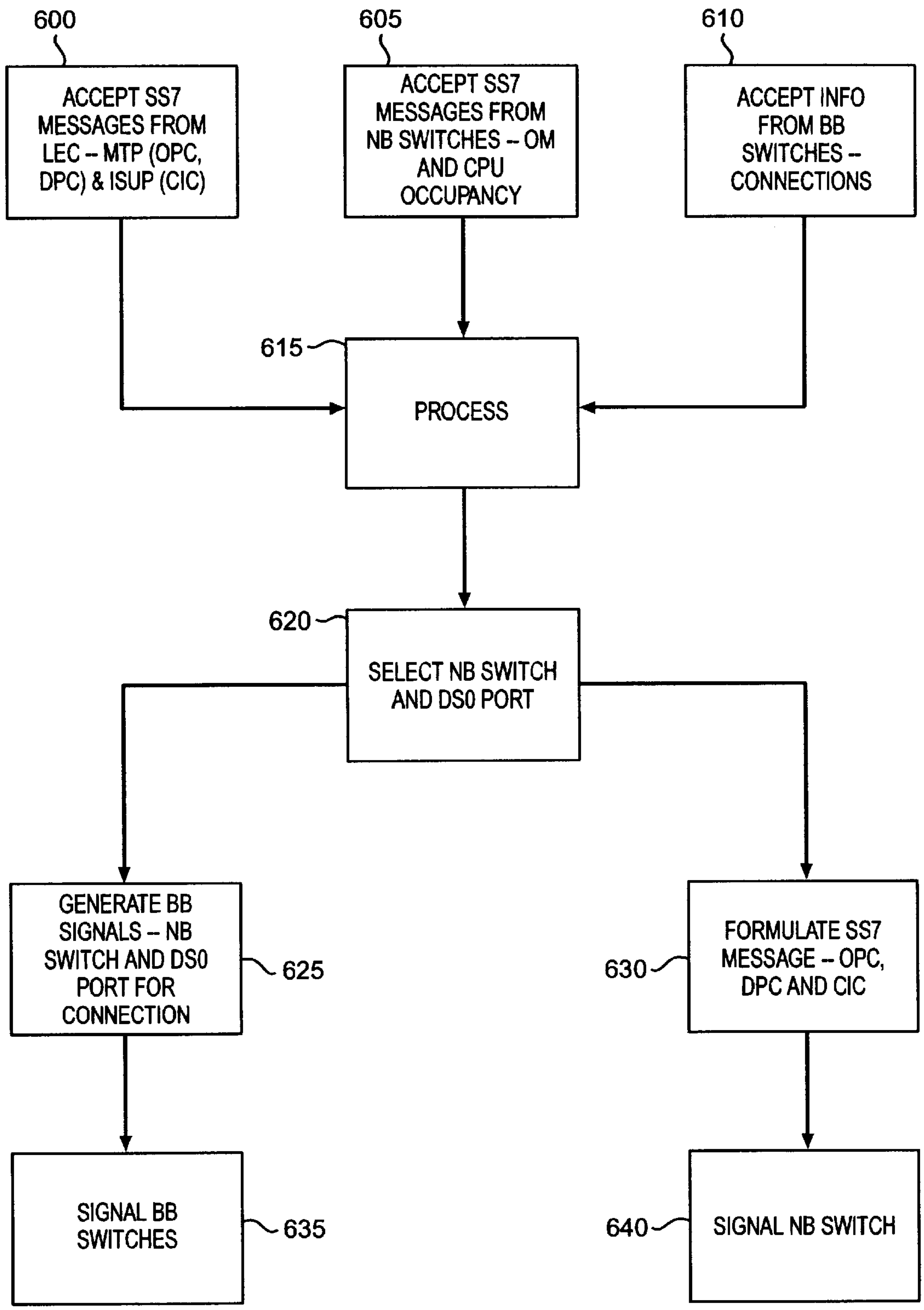

600
ACCEPT SS7 MESSAGES FROM LEC -- MTP (OPC, DPC) & ISUP (CIC)
605
ACCEPT SS7 MESSAGES FROM NB SWITCHES -- OM AND CPU OCCUPANCY
610
ACCEPT INFO FROM BB SWITCHES -- CONNECTIONS
615
PROCESS
620
SELECT NB SWITCH AND DS0 PORT
GENERATE BB SIGNALS -- NB SWITCH AND DS0 PORT FOR CONNECTION
625
630
FORMULATE SS7 MESSAGE -- OPC, DPC AND CIC
SIGNAL BB SWITCHES
635
640
SIGNAL NB SWITCH

FIG. 6

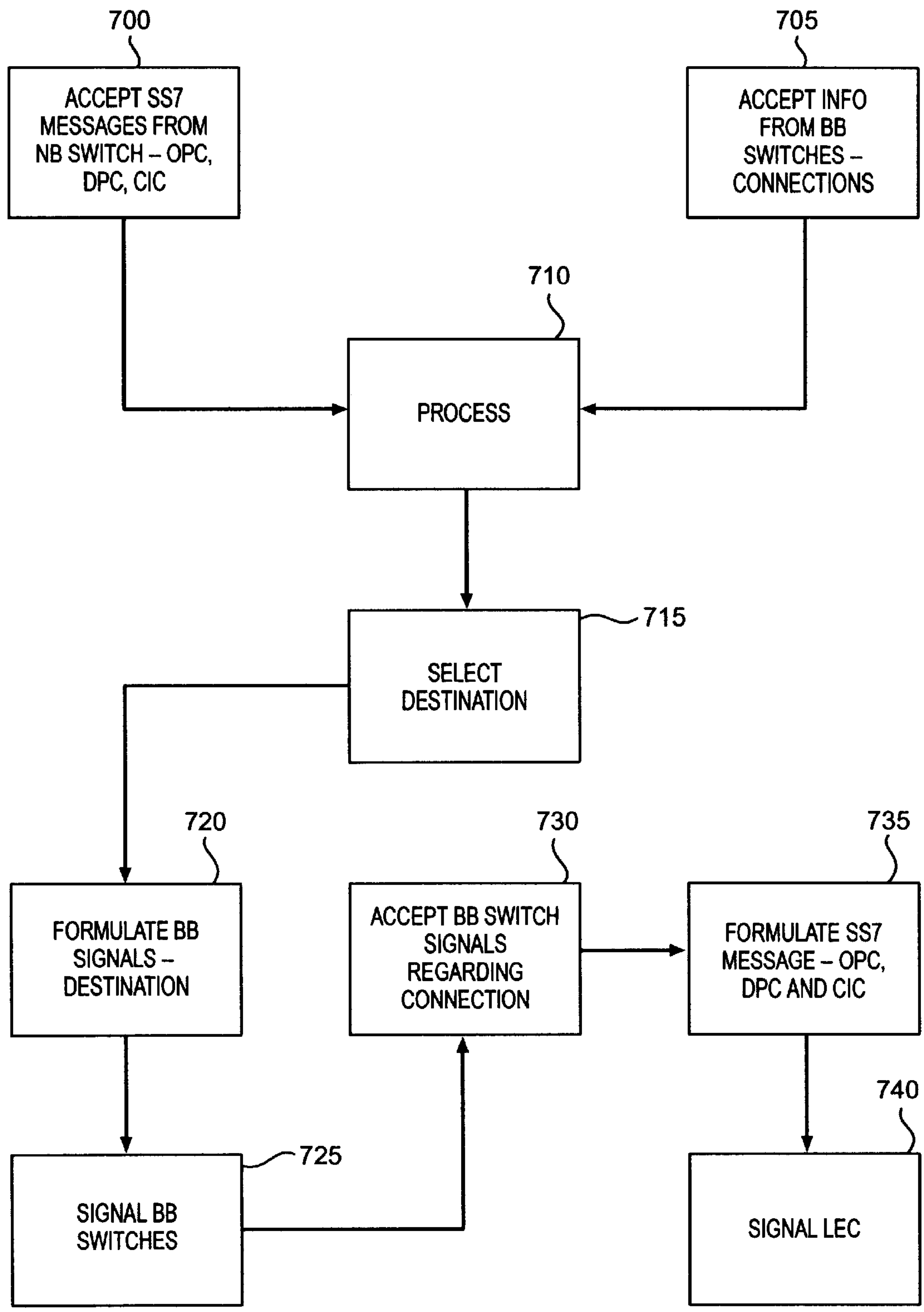

700
ACCEPT SS7 MESSAGES FROM NB SWITCH – OPC, DPC, CIC
705
ACCEPT INFO FROM BB SWITCHES – CONNECTIONS
710
PROCESS
715
SELECT DESTINATION
720
FORMULATE BB SIGNALS – DESTINATION
730
ACCEPT BB SWITCH SIGNALS REGARDING CONNECTION
735
FORMULATE SS7 MESSAGE – OPC, DPC AND CIC
725
SIGNAL BB SWITCHES
740
SIGNAL LEC

FIG. 7

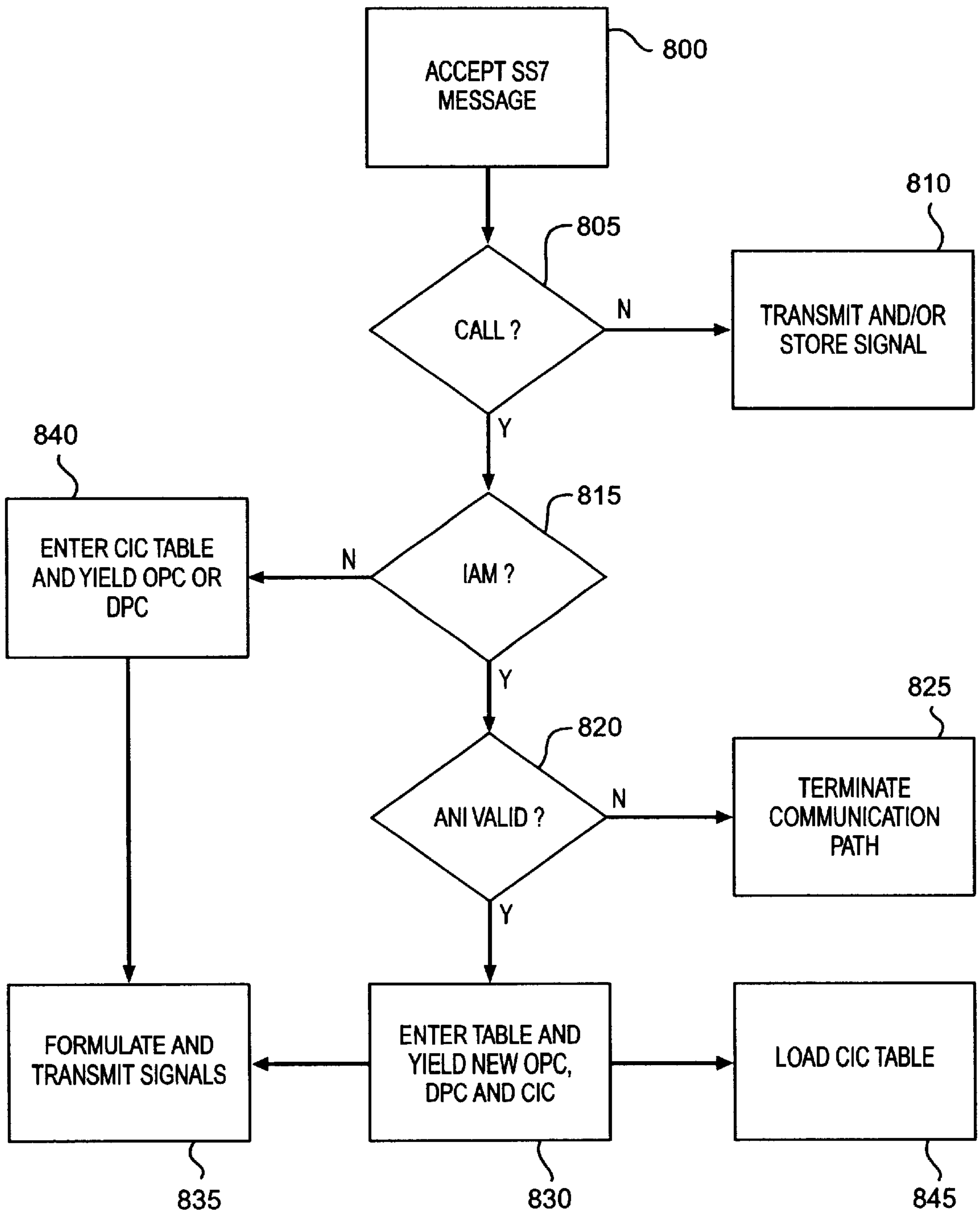

ACCEPT SS7 MESSAGE
800
CALL ?
805
N
Y
TRANSMIT AND/OR STORE SIGNAL
810
IAM ?
815
N
Y
ENTER CIC TABLE AND YIELD OPC OR DPC
840
ANI VALID ?
820
N
Y
TERMINATE COMMUNICATION PATH
825
FORMULATE AND TRANSMIT SIGNALS
835
ENTER TABLE AND YIELD NEW OPC, DPC AND CIC
830
LOAD CIC TABLE
845

FIG. 8

METHOD, SYSTEM AND APPARATUS FOR TELECOMMUNICATIONS CONTROL

RELATED APPLICATIONS

This application is a continuation of application Ser. No. 09/082,040, filed on May 20, 1998, which is a continuation of application Ser. No. 08/568,551, filed on Dec. 7, 1995, now U.S. Pat. No. 5,825,780 which is a continuation of U.S. patent application Ser. No. 08/238,605, filed on May 5, 1994 and now abandoned. U.S. patent application Ser. Nos. 09/082,040, 08/568,551, 08/238,605 and 08/568,551 are hereby incorporated by reference into this application.

FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not Applicable

MICROFICHE APPENDIX

Not Applicable

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to telecommunications and more specifically to communications control processing in telecommunications signaling.

2. Description of the Prior Art

Telecommunications systems establish a communications path between two or more points to allow the transfer of information between the points. The communications path typically comprises a series of connections between network elements. The network elements are typically switches. Switches provide the primary means where different connections are associated to form the communications path. Communication control is the process of setting up a communications path between the points. Communication control comprises the selection of network elements such as switches or other devices which will form part of the communications path. Communication control also comprises the selection of the connections between the network elements. Together, control also comprises the selection of the connections between the network elements. Together, the network elements and connections which are selected make up the communications path. Typically, a plurality of different network element and connection selections may be possible for any one communications path between points.

Switches control these selections. Switches select the connections that comprise the communications path. Switches also select the network elements which form an actual part of that communications path. By selecting these network elements, a switch is often selecting the next switch that will make further selections. Switches accomplish communication control.

The correspondence between communication control and a communications path is well known in the art. A common method used in communication control is signaling among switches. One method by which a first point requests a communications path to a second point is by signaling a first switch with an off-hook signal followed by dual tone multifrequency (DTMF) signals. The first switch will typically process those signals and will select other network elements such as a second switch. The first switch signals the second switch and establishes a connection between the switches. The second switch then selects the next network element, signals that network element, and establishes a connection to that network element. This process is well known in the art. The connections and signaling thus proceed from switch to switch through the network until a communications path is established between the first and second points.

Some networks transmit signaling information from the switches to other signaling devices. In these cases, the switches typically must be modified through the use of Signaling Point (SP) hardware and software in order to convert the language of the switch into the language used by these other signaling devices. One signaling device is a Service Control Point (SCP). An SCP processes signaling queries from a switch. An SCP only answers a switch query after the switch has become a part of the communications path. SCPs support the communication control which is directed by the switch.

Additionally, signaling may pass through other signaling devices, such as Signal Transfer Points (STPs), which route the signaling. An STP is typically a high-speed packet data switch which reads portions of the signaling information and either discards or routes the information to a network element. The signal routing operation of the STP is based on the signaling information that is specified by the switch. STPs route signaling information, but STPs do not modify or otherwise process the signaling information. An example of the above described system is Signaling System #7 (SS7) technology. Thus, signaling devices only are used to support switches in communication control.

Broadband systems, such as Asynchronous Transfer Mode (ATM) may use extensions of existing SS7 signaling to allow ATM switches to direct communication control. However, broadband systems may also utilize different communication control methods. ATM switches may transfer ATM cells which contain signaling to other ATM switches. As with the other switch types however, ATM switches also perform the dual task of communication control and forming a part of the communications path.

Some switches use API switching which employs remote central processing units (CPUs). These switches only receive switch information from the remote CPUs and not signaling. The protocols used for information transfer between the switch and the remote CPU are proprietary among vendors and are incompatible between the switches of different vendors.

Some digital cross-connect (DCS) equipment employ centralized control systems. These systems, however, only provide relatively static switching fabrics and do not respond to signaling. Instead of establishing connections in response to signaling, DCS cross-connections are established in response to network configuration needs. Network elements and connections are pre-programmed into the network and are not selected in response to signaling from a point outside of the network.

At present, while communication control and the communications path are distinct from one another, both are dependent on the switch. The performance of both of these tasks by switches places limitations on a telecommunications network. One such limitation can be illustrated by one difficulty encountered in combining narrowband networks and broadband networks. Broadband networks are advantageous for data transmission because virtual permanent connections can be mapped through a network and bandwidth allocated on demand. Narrowband switches are advantageous for voice, in part, due to the many features which have been developed in conjunction with these switches. These features benefit both the user and the network through added efficiency and quality. Examples are "800" platforms, billing

systems, and routing systems. However for broadband networks, the development of these features is incomplete and does not provide the functionality of current narrowband features. Unfortunately, narrowband switches do not have the capacity, speed, and multimedia capabilities of broadband switches. The resulting combination is separate overlay networks. Typically, narrowband traffic remains within the narrowband network, and broadband traffic remains within the broadband network.

Any intelligent interface between the two networks would require that signaling information be transmitted between narrowband switches and broadband switches. At present, the ability of these switches to signal each other is limited. These switch limitations create a major obstacle in any attempt to interface the two networks. It would be advantageous if narrowband and broadband networks could interwork through an intelligent interface to establish a communications path between points. At present, the interface between narrowband and broadband networks remains a rigid access pipe between overlay systems.

The reliance on switches to both perform communication control and to form the a part of the communications path results in impediments to developing improved networks. Each time a new network element, such as a broadband switch, is introduced, a telecommunications network may be forced to delay integrating the network element into its network until standardization of signaling and interface protocols are developed for the switches. At present, there is a need for a portion of the communication control processing to be independent of the switches that form a part of the communications path.

SUMMARY

An embodiment of the present invention solves this need by providing a method, system, and apparatus for communication control processing that is located externally to the switches that make the connections. The method includes receiving a first signal into a processor which is located externally to the switches in a network comprised of network elements. The processor selects a network characteristic in response to the first signal. The processor then generates a second signal reflecting the network characteristic and transmits the second signal to at least one network element. This transmission occurs before that network element has applied the first signal. Examples of network characteristics are network elements and connections, but there are others. Examples of signaling are Signaling System #7 or broadband signaling. The processor may also employ information received from the network elements or operational control when making selections. In one embodiment, the method includes receiving the first signal into a network from a point and routing the first signal to the processor.

The present invention also includes a telecommunications processing system which comprises an interface that is external to the switches and is operational to receive and transmit signaling. The processing system also includes a translator that is coupled to the interface and is operational to identify particular information in the received signaling and to generate new signaling based on new information. The processor also includes a processor that is coupled to the translator and is operational to process the identified information from the translator in order to select at least one network characteristic. The processor provides new information to the translator reflecting the selection. The identified information is used in the processor before it is used in the particular network elements that receive the new signaling.

The present invention also includes a telecommunications network comprised of a plurality of network elements wherein at least one network element is a switch, and a plurality of connections between the network elements. The network also includes a processor located externally to the switches which is operable to receive a first signal, to select at least one network characteristic in response to the first signal, and to generate a second signal reflecting the selection. The network also includes a plurality of links between the processor and the network elements which are operable to transmit the second signal to at least one network element before that network element has applied the first signal.

The present invention also includes a telecommunications signaling system for use in conjunction with a plurality of telecommunication switches. This system comprises a plurality of signaling points and a signaling processor. The signaling processor is linked to the signaling points and resides externally to the switches. The signaling processor is operational to process signaling and to generate new signaling information based on the processing. The new signaling is transmitted over the links to multiple signaling points. In one embodiment, the new signaling information is comprised of different signaling messages and the different signaling messages are transmitted to different signaling points.

In another embodiment, a plurality of the signaling points each reside in a different switch and are directly coupled to a processor in the switch that directs a switching matrix in the switch in response to signaling processed by the signaling point. The signaling processor is operational to direct the switching matrixes of multiple switches by signaling multiple signaling points. The signaling processor is also operational to signal multiple points in response to signaling from a single source, and to signal a point in response to signaling from multiple sources.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features, aspects, and advantages of the present invention will become better understood with regard to the following description, claims, and drawings where:

FIG. **1** is a block diagram of a version of the invention.

FIG. **2** is a block diagram of a version of the invention.

FIG. **3** is a block diagram of a version of the invention.

FIG. **4** is a logic diagram of a version of the invention.

FIG. **5** is a flow diagram of a version of the invention.

FIG. **6** is a flow diagram of a version of the invention.

FIG. **7** is a flow diagram of a version of the invention.

FIG. **8** is a flow diagram of a version of the invention.

DESCRIPTION

Telecommunications systems establish communications paths between points which allow the points to transfer information, such as voice and data, over the communication paths. Typically, telecommunications systems are comprised of network elements and connections. A network element is a telecommunications device such as a switch, server, service control point, service data point, enhanced platform, intelligent peripheral, service node, adjunct processor, network element of a different network, enhanced system or other network related device, server, center or system.

A connection is the media between two network elements that allows the transfer of information. A few examples of connections are: digital T1 lines, OC-3 optical fibers, packet connections, dedicated access lines, microwave

transmission, and cellular radio. As those skilled in the art are aware, connections can be described in a range from general to specific. All of the media between two switches is a general description and might correspond to a virtual path in an ATM system or a trunk groups in a T1 system. An individual circuit between two elements is more specific and might correspond to a virtual channel in an ATM system or a DS0 circuit in a T1 system. Connections can also be described as being logical or physical. Physical connections are electrical-mechanical media. Logical connections are paths which follow physical connections, but are differentiated from one another based on format and protocol. The term "connection" includes this entire range and the meaning varies according to the context in which the term is used. The present invention could make selections encompassing the entire range of connections.

A communications path is the combination of connections and network elements that physically transfers the information between points. A communication path may be point to point, point to multi-point, or multi-point to multi-point. These points, in turn, define the ends of the communications path. Thus, a connection may also be made between a network element and a point outside the network.

Signaling is the transfer of information among points and network elements and is used to establish communications paths. An example is Signaling System #7 (SS7). Signaling is typically transmitted over links, such as 56 kilobit lines. On the block diagrams, signaling is represented by dashed lines and connections are represented by solid lines.

In FIG. **1**, Telecommunications System **110** comprises a communication control processor (CCP) **120** and first, second, third, fourth, fifth and sixth network elements, **131**, **132**, **133**, **134**, **135** and **136** respectively. First and second network elements, **131** and **132** respectively, are connected by first connection **141**. First and third network elements, **131** and **133** are connected by both second and third connections, **142** and **143** respectively. First and fifth network elements, **131** and **135** respectively, are connected by fourth connection **144**. Second and fourth network elements, **132** and **134** are connected by fifth connection **145**. The third network element **133** is connected to fourth and sixth network elements, **134** and **136** by sixth and seventh connections, **146** and **147** respectively. Fourth and fifth network elements, **134** and **135** are connected by connection **148**. A first point **170**, which is located outside of the system **110**, is connected to first element **131** by first point connection **171**, and a second point **172** which is also located outside the system **110** is connected to fourth element **134** by second point connection **173**. First and second point, **170** and **172** respectively and first, second, third, fourth, fifth and sixth elements **131**, **132**, **133**, **134**, **135**, and **136** respectively each are linked to CCP **120** by first, second, third, fourth, fifth, sixth, seventh, and eighth links, **191**, **192**, **193**, **194**, **195**, **196**, **197** and **198** respectively.

As those skilled in the art are aware, a system is typically comprised of many more network elements, links, connections and points, but the number is restricted for clarity. Points outside of the network can take many forms, such as customer premises equipment (CPE), telephones, computers, or switches of a separate network system. In addition the system **110**, may take many forms such as international gateways, satellite networks, wireless networks, local exchange carriers (LECs), interexchange carriers (IXCs), transit networks, national networks, personal communicator systems (PCS), virtual private networks, or connection oriented networks such as local area networks (LANs), metropolitan area networks (MANs), wide area networks (WANs) to name some examples.

In operation Telecommunications System **110** is able to accept information from first point **170** and second point **172** and transmit the information over the various network elements and connections which form the communications path. System **110** is also capable of exchanging signaling with first point **170** and second point **172** over the first link **191** and second link **192**.

On a standard call that establishes a communications path from first point **170** to second point **172**, first point **170** will signal Telecommunications System **110** that it requests the communications path. This signaling is directed to CCP **120** over first link **191**. CCP **120** processes the signaling and selects at least one network characteristic in response to the signaling. Network characteristics might be network elements, connections, network codes, applications, or control instructions to name a few examples. The selected network characteristic typically comprises one of a plurality of network elements and/or connections. The CCP **120** generates signaling which is preferably new signaling reflecting the selection. CCP **120** then transmits the signal to at least one of a plurality of network elements before that network element has applied the signal.

In one embodiment, CCP **120** selects the network elements and the connections that comprise the communications path. However, first point **170** will typically seize first point connection **171** contemporaneously with signaling. This initial connection could also be selected by CCP **120** from the available possibilities after the signaling by first point **170**. Assuming first point **170** has seized first point connection **171** to first element **131**, CCP **120** selects one, a plurality, or all of the remaining network elements and connections to further establish a communications path to second point **172**.

CCP **120** determines which element should be connected to first element **131**. CCP **120** could select either second element **132** or third element **133**. If third element **133** is selected, CCP **120** may also select the connection to third element **133** from among second and third connections, **142** and **143** respectively. If third connection **143** is selected, CCP **120** will signal first element **131** over third link **193** to further the communications path to third element **133** over third connection **143**.

CCP **120** may then make further selections to complete the communications path. As the possibilities have been limited for clarity. CCP **120** would make the selections and signal the elements as follows. CCP **120** would signal third element **133** over fifth link **195** to further the communications path to fourth element **134** over sixth connection **146**. CCP **120** would signal fourth element **134** over sixth link **196** to further the communications path to second point **172** over second point connection **173**. CCP **120** would also signal second point **172** over second link **192** of the communications path available through second point connection **173**. In this way, the communications path requested by first point **170** is selected by CCP **120** and signaled to the elements. Throughout this process, CCP **120** may receive status messages and signaling from the elements to support its processing. This status messaging may be transmitted and received over links, connections, or other communication means.

In another embodiment, CCP **120** may select only the network elements and not the connections. The elements would select the connections to use based on the network element selected by CCP **120**. For this embodiment, the main difference from the above example is that CCP **120** would instruct first element **131** to further the communica-

tions path to third element **133**, but first element **131** would select the actual connection used from among second and third connections, **142** and **143**, respectively. First element **131** may signal CCP **120** over third link **193** of its selection so that CCP **120** may signal third element **133** of the connection over fifth link **195**. In this embodiment, CCP **120** would specify the network elements to the elements, which in turn, would select the connections between those network elements.

There are situations in which the selection of a network element and the selection of a connection signify the same thing. On FIG. **1** for example, instructing first element **131** to use first connection **141** is synonymous with an instruction to connect to second element **132**. This is because the connection inevitably connects to the element. The selection of a connection may effectively select a network element, and the selection of a network element may effectively select a connection (or a group of specific connections) to that network element.

One skilled in the art will recognize that the selection process can be distributed among the CCP and the elements. The CCP might select all the network elements, a portion of the network elements, or none of the network elements leaving the switches to select the remainder. The CCP might select all of the connections, a portion of the connections, or none of the connections, again leaving the elements to select the remainder. The CCP may select combinations of the above options, but the CCP will always select at least one network characteristic.

In another embodiment, first point **170** may want to access a other network elements such as servers, platforms or operator centers. For example, such elements could be located at either fifth or sixth network elements **135**, and **136** respectively. CCP **120** will receive signaling from first point **170** over first link **191** indicating this request, and first point **170** will typically seize first point connection **171** to first element **131**. Again CCP **120** will select network elements. If sixth element **136** is selected, CCP **120** could select a communications path from first element **131** through either second element **132** to fourth element **134** and then to third element **133**, or through a direct connection from first element **131** to third element **133**. If CCP **120** selects the latter, it would signal first element **131** to further the communications path to third element **133**, and it would signal third element **133** to further the communications path to sixth element **136**. As discussed in the above embodiments, CCP **120** may also select the connections, or the elements may be left with that task.

As is known in the art, in-band signaling is typically used in many user to network connections, such as the local loop. This is because only one connection or link is typically provided to the user premises and thus, the signaling must be placed on the actual communications path. The initial network switch typically removes the signaling from the communications path and transfers it to an out-of-band signaling system. The current invention is fully operational in this context. Although the switch may receive the signaling initially, it will only route the signaling to the CCP for processing. Even if in-band signaling is used within the network, the switches could remove signaling from the communications path and route it to the CCP for processing in accord with the present invention.

Thus, preferably the CCP processes signaling before it is applied or processed by the switch such as to select connections or generate queries. Preferably, no or minimal changes are made to the signaling prior to the signaling

being received by the CCP so that the CCP receives the signaling in the same format as a switch would receive the signaling. The CCP may also process the signaling in that format. The switches make their selections based on the CCP selections, thus the switch selections clearly occur after the CCP has processed the signaling. As such, the switch may route signaling to the CCP, but the switch does not apply the signaling. Some examples of a switch applying the signaling would be selecting network elements or generating queries for remote devices.

In one of the above embodiments, the switches did not select the network elements and connections, initiate the signaling, or otherwise control the communication. The switches only followed the instructions of the CCP and actually made the connections that furthered the communications path. In one embodiment, the switches were allowed to select the actual connections used, but even these selections were based on CCP selections.

As illustrated above, the CCP allows a telecommunications network to separate communication control from the communications path. In prior systems, the switches would select the network elements and the connections, as well as, actually providing a part of the actual connection. As a result, prior systems are restricted to the communication control capabilities provided by the switches. Prior systems have used remote devices, such as an SCP, to support switch control, but the remote device only answered queries in response to the switches processing of the signal. These remote devices do not process the signaling before the switch had already applied the signaling. By using the CCP, telecommunications systems can control communications independently of the capability of the switches to accomplish both tasks.

FIG. **2** shows a block diagram of another embodiment of the present invention. CCP **250** and network **210** are shown. CCP **250** is a communications control processor. CCP **250** could be integrated into network **210**, but need not be and is shown separately for clarity. Network **210** could be any type of telecommunications network that operates using network elements, signaling, and connections. Examples would be LECs, IXCs, LANs, MANs, WANs, and Cellular Networks, but there are others. Additionally, network **210** could be narrowband, broadband, packet-based, or a hybrid. Network **210** is capable of providing communications paths between points both inside and outside of network **210**. CCP **250** and network **210** are linked by link **214** and are able to signal each other in order to establish these paths.

Additionally, user **220**, and user **230** are shown and are also capable of signaling. Examples of users **220** and **230** might be telephones, computers, or even switches in another telecommunications network. Users **220** and **230** are connected to network **210** by connections **222** and **232** respectively. Users **220** and **230** are linked to CCP **250** by links **224** and **234** respectively. Signaling may be transmitted over links **224** and **234**. If in-band signaling is employed on connections **222** and **232**, network **210** would separate at least a portion of the signaling out-of-band and transmit it to CCP **250** over link **214**.

Also shown are various network elements. As with CCP **250**, these elements could also be integrated into network **210**, but are shown separately for clarity. These network elements are: networks **260**, operator centers **262**, enhanced platforms **264**, video servers **266**, voice servers **268**, and adjunct processors **270**. This is not an exclusive list. Those skilled in the art will recognize these network elements and their functions, as well as the many other types of telecom-

munications devices, such as billing servers, that are applicable in this situation.

Each network element is connected to network **210** by connection **212**. Connection **212** represents several actual connections between the network elements **(260–270)** and different elements in network **210**. One bus-type connection is shown for purposes of clarity, but those skilled in the art are familiar with many actual types of connections to use. Additionally link **256** is shown from CCP **250** to the network elements **(260–270)**. Link **256** is similarly represented as a bus-type link for clarity, and multiple links are actually used, although some network elements may not even require links. Link **214** has been simplified for clarity in the same fashion.

In one embodiment, user **220** may desire to establish a communications path to user **230**. CCP **250** would make the appropriate selections and signal the net elements in network **210** as discussed with regard to the embodiments of FIG. **1**. As a result, a communications path would be established from user **220** to user **230** through network **210** and connections **222** and **232**.

In another embodiment, user **220** may desire to access one of the various network elements **(260–270)**. User **220** will typically seize connection **222** to network **210** and generate signaling. Both in-band signaling on connection **222** and out-of-band signaling on link **224** would be directed to CCP **250**. By processing the signaling, CCP **250** can select any of the network elements **(260–270)** and control the communications through network **210** and connection **212** to the network elements **(260–270)**.

For example, should user **220** desire to connect to a video server and another network, user **220** would signal the request. The signaling would be directed to CCP **250** over link **224**, or over connection **222** and link **214** as discussed above. CCP **250** would process the signaling and make the appropriate selections. CCP **250** would signal network **210** and video servers **266** of its selections. As a result, a communications path would be set-up from user **220** to video servers **266**.

Additionally, CCP **250** would control communications to the other network which is represented by networks **260**. Networks **260** could be any other form of telecommunications network-either public or private. CCP **250** would make the appropriate selections to further the communications path over connection **212** and network **210** to networks **260**. Upon signaling from CCP **250**, the connections comprising the communications path would be made. Networks **260** would also be signalled by CCP **250** over link **256**. As such a communication path is set up from user **230** to video servers **266** and on to networks **260**.

There may also be several devices represented by particular network element shown on FIG. **2**. CCP **250** could also select the particular device to access. For example, take the situation in which voice servers **268** represents 20 individual voice server devices split among three different locations. On each call, CCP **250** could select the actual voice server device which should be used on that call and control the communications through network **210** and connection **212** to the selected device. Alternatively, CCP **250** may only be required to select group of devices, for instance at a particular location, instead of the actual device.

As is known, large telecommunication networks are comprised of numerous network elements, connections, and links. The present invention is suitable for use in this context. FIG. **3** shows a version of the present invention in the context of a large network. Typically, this network would be comprised of several broadband switches, narrowband

switches, muxes, signal transfer points (STPs), Service Control Points (SCPs), operator centers, video servers, voice servers, adjunct processors, enhanced services platforms, connections, and links. For purposes of clarity, only a few of these possibilities are shown on FIG. **3**. For the same reason, connections and links are not numbered.

FIG. **3** shows Telecommunications Network **310** which is comprised of STP **340**, STP **345**, CCP **350**, SCP **355**, broadband switches **360**, **362**, **364**, and **366**, interworking units **361** and **365**, narrowband switches **370** and **375**, and muxes **380**, **382**, **384**, and **386**. Aside from CCP **350**, these elements of a large network are familiar to one skilled in the art and examples of the of these network elements are as follows: STP—DSC Communications Megahub; SCP—Tandem CLX; broadband switch—Fore Systems ASX-**100**; narrowband switch—Northern Telecom DMS-**250**; and mux—Digital Link PremisWay with CBR module.

In at least one embodiment, the broadband switches are equipped with signaling interworking units. These units translate SS7 messages into B-ISDN messages. In that event, the CCP could transmit SS7 to the broadband switches which could convert the signals properly. Interworking is discussed in ITU-TS Recommendation Q.2660, "B-ISDN, B-ISUP to N-ISUP Interworking".

When user information passes from a broadband network to a narrowband network, it typically must pass through a mux. Muxes can convert transmitted information back and forth between narrowband and broadband formats. In at least one embodiment, each broadband connection on one side of a mux corresponds to a narrowband connection on the other side of the mux. In this way, the CCP can track connections through the mux. If the communication path is on a given narrowband connection entering the mux, it will exit the mux on its corresponding broadband connection. This correspondence allows the CCP to identify connections on each side of the mux based on the entry connection. Muxes are typically placed at any interface between narrowband and broadband connections.

As long as the connections correspond through the mux, the CCP can track the communication path properly. Alternatively, the connections may not correspond. In that case, signaling links between the muxes and the CCP would be required for the devices to communicate and allow the CCP to track the communication path.

Additionally, Telecommunications Network **310** includes the connections and links which are not numbered. These connections and links are familiar to those skilled in the art. Some examples of possible connections are switched digital lines, satellite links, microwave links, cellular links, and dedicated digital lines, but there are others. The signaling links are typically data links, such as 56 kilobit lines. The signaling may employ SS7,Broadband, C6, C7, CCIS, Q.933, Q.931, T1.607, Q.2931, B-ISUP or other forms of signaling technology. The present invention is fully operational with the many variations which are well known in the art. Additionally, it is also known that a direct link between two devices can be used instead of an STP for signal routing.

Outside of Telecommunications Network **310** are first point **320**, second point **330**, LEC switch **325**, LEC switch **335**, LEC STP **328**, and LEC STP **338**. These devices are shown along with their links and connections. First point **320** is connected to LEC switch **325**. LEC switch **325** is linked to LEC STP **328** which routes signaling from LEC switch **325**. LEC switch **325** is also connected to mux **380** of Telecommunications Network **310**. LEC STP **228** is linked to STP **340** of Telecommunications Network **310**.

STP **340** is linked to STP **345**. The other links are as follows. STPs **340** and **345** are linked to CCP **350**. CCP **350** is linked to interworking units **361** and **365** of broadband switches **360** and **364** respectively. CCP **350** is linked to broadband switches **362** and **366**, and narrowband switch **375**. STP **345** is linked to narrowband switch **370** and SCP **355**. STP **345** is also linked to LEC STP **338** which is linked to LEC switch **335**.

Mux **380** is connected to broadband switch **360**. Broadband switch **360** is connected to broadband switches **362** and **364**. Broadband switch **362** is connected to mux **384** which is connected to narrowband switch **375**. Broadband switch **364** is connected to mux **382** which is connected to narrowband switch **370**. Broadband switches **362** and **364** are both connected to broadband switch **366**. Broadband switch **366** is connected to mux **386** which is connected to LEC switch **335**. LEC switch **335** is connected to second point **330**.

When a call is placed from first point **320** that requires the use of Telecommunications Network **310**, LEC switch **325** will typically seize a connection to Telecommunications Network **310** and generate a signal containing call information. At present, this signal is in SS7 format and the seized connection is a DS0 port. The signal is transmitted to LEC STP **328** which transfers it on to STP **340**. LEC switch **325** also extends the communication path over the seized connection. These LEC components and the process of establishing communication paths between a point, a LEC, and an IXC are familiar to those skilled in the art.

Telecommunications Network **310** accepts the communication path on the narrowband side of mux **380**. The present invention can also accept broadband calls that do not require a mux, but typically, calls from a LEC will be narrowband. Mux **380** converts the call to broadband and places it on the broadband connection that corresponds to the seized connection. The communication path extends to broadband switch **360** through mux **380**.

STP **340** transfers the signal from LEC STP **328** to STP **345** which, in turn, routes the signal to CCP **350**. Also, CCP **350** accepts status messages from the broadband and narrowband switches over standard communications lines, and may query SCP **355** for information. Any suitable database or processor could be used to support CCP **350** queries. CCP **350** uses this information and its own programmed instructions to make communication control selections. For calls that require narrowband switch treatment, CCP **350** will select the narrowband switch.

Preferably, CCP **350** can select any narrowband switch in Telecommunications Network **310**. For example, it may extend the communication path through the broadband network to a narrowband switch across the network for processing, or it may extend the communication path to a narrowband switch connected to the broadband switch that originally accepts the communication path. Additionally, no narrowband switch may be required at all. For clarity, all of the switches representing these possibilities are not shown on FIG. **3**.

CCP **350** will select at least one network characteristic in response to the signaling. Typically, this will be the network elements or connections that will make the communication path. As discussed with regard to the above embodiments, CCP **350** may select only the network elements and allow the switches to select the connections, or the selections can be distributed among the two. For example, CCP **350** may only select some of the network elements and connections and allow the switches to select some of the network elements and connections. CCP **350** might only select the

narrowband switches and allow the broadband switches to select the broadband switches that will make the communication path. CCP **350** can also select other network characteristics, such as applications and control instructions.

In one embodiment, CCP **350** will select the narrowband switches to process particular calls and the DS0 ports on those switches which will accept these calls. The broadband switches will select the broadband switches and the broadband connections to the DS0 port. Restricted to the possibilities depicted on FIG. **3**, CCP **350** may select either narrowband switch **370** or narrowband switch **375** to process the call. Assuming CCP **350** selects narrowband switch **370**, it would also select a DS0 port on narrowband switch **370** to accept the connection. CCP **350** would then signal broadband switch **360** through interworking unit **361** to farther the communications path to the selected DS0 port on narrowband switch **370**.

Of the possible routes, broadband switch **360** would be left to select the other broadband switches and connections to use. Assuming the route directly to broadband switch **364** is selected, broadband switch **360** would further the communications path to that switch. Broadband switch **360** would also signal broadband switch **364** of the communication path. Broadband switch **364** would further the communication path to through mux **382** to access the specified DS0 port on narrowband switch **370**. This is accomplished by corresponding the connections through the mux as discussed above. CCP **350** will signal narrowband switch **370** of the incoming communication path. This signal is routed by STP **345**. Narrowband switch **370** will process the call on the specified DS0 port. Typically, this would include billing and routing the call. Narrowband switch **370** may also query SCP **355** to aid in application of services to the call. For example, narrowband switch **370** may retrieve an "800" translation from SCP **355**. As a result of the processing, narrowband switch **370** will switch the call and generate a new signal which may include routing information. The signal is sent to CCP **350** through STP **345**. The communication path is furthered on a new connection back to broadband switch **364** through mux **382**. CCP **350** may use the information in the signal, SCP information, network element information, operational instructions, and/or its own routing logic to make new selections for the call. The network element information and operational instructions could be signalled to CCP **350** or delivered over standard data lines.

In one embodiment, the selection of a network characteristic will include the selection of a network code. Network codes are the logical addresses of network elements. One such code is a destination code that facilitates egress from Telecommunications System **310**. The destination code typically represents a network element that is connected to a LEC switch. Once a destination is selected, CCP **350** will signal broadband switch **364** of its selections and the communication path will be furthered through the broadband network accordingly. In the current example this could be through broadband switch **366** and mux **386**. The communication path would be furthered to the specified port on LEC switch **335**. Typically, this involves the seizure of a connection on the LEC switch by the IXC.

In one embodiment, whenever broadband switch **366** extends a communication path to mux **386**, it is programmed to signal CCP **350** of the broadband connection it has selected. This allows CCP **350** to track the specific DS0 port on the LEC switch that has been seized. CCP **350** would signal LEC switch **335** through STP **345** and LEC STP **338** of the incoming call on the seized DS0 connection. As a

result, LEC switch **335** would further the communication path to second point **330**.

It can be seen from the above disclosure that the present invention allows a telecommunications network to employ a broadband network to make call connections. By using muxes to convert calls and a CCP to analyze signaling, this broadband network remains transparent to the networks of other companies. An example of such a transparent interface is between an interexchange carrier (IXC) network and a local exchange carrier (LEC) network. Similarly the network will be transparent if deployed in only a portion of a single company's network infrastructure.

In the above embodiment, the LEC seizes an IXC DS0 port and signals to an IXC STP. The mux and the CCP convert the call and analyze the signal appropriately. No changes in other existing carrier systems, such as LEC systems, are required.

Additionally the narrowband switch receives the call and signal in its own format and switches the call. Although the switch may "think" the call is routed over a trunk to another narrowband switch, the call actually goes right back to the mux and broadband switch that sent the call. The narrowband switch is used to apply features to the call, i.e. billing, routing, etc. The broadband network is used to make the substantial portion of the call connection. The CCP may use narrowband switch call processing information to make selections.

The CCP performs many functions. In one embodiment, it accepts signaling from a first point or LEC and provides appropriate signals in accord with the communication control selections it has made. These selections are network characteristics. The CCP may select network elements such as switches, servers, or network codes. The CCP may select connections, such as DS0 circuits and ports. The CCP may select particular telecommunications applications to be applied to the communications path. The CCP may select particular control instructions for particular devices. The CCP may also receive information from entities such as SCPs, operational control, or switches to aid in its selections.

The CCP is a processing system, and as such, those skilled in the art are aware that such systems can be housed in a single device or distributed among several devices. Additionally, multiple devices with overlapping capabilities might be desired for purposes of redundancy. The present invention encompasses these variations. One such operational system would be multiple pairs of CCPs located regionally within a telecommunications system. Each machine would be equally capable of communication control. One example of a CCP device would be a Tandem CLX machine configured in accord with this disclosure of the present invention.

A signaling point handles the signaling for a switch. Switches which are used to route calls typically have a signaling point which is directly coupled to a processor in the switch. This processor controls a switching matrix in the switch in response to the signaling processed by the signaling point. Thus, there is typically a one to one correspondence of a signaling point for each switch and matrix.

The CCP is not directly coupled to one switch, one switch processor (CPU), or one switching matrix. In contrast, the CCP has the capability of directing a plurality of switches. Thus, the CCP can direct multiple switch matrixes by signaling multiple signaling points.

It is possible to house the CCP within other telecommunication devices, even switches. Although the CCP can be primarily distinguished from a switch CPU based on physical location, this does not have to be the case. A switch CPU receives information from a signaling point and controls the matrix of a single switch. Some switches distribute the matrix among different physical locations, but the CPU controls each matrix based on information received from a single signaling point This information is not signaling.

In contrast, the CCP receives signaling and has the ability to signal other network elements. It can communicate with multiple signaling points. These signaling points provide information to the switch CPUs which control the switch matrixes. By signaling multiple signaling points, the CCP is able to direct the matrixes of multiple switches based on the signaling and other information the CCP obtains. A CCP is not associated with a single switch matrix. A CCP does not require communication path connections in order to operate.

The main capabilities of one version of a CCP are shown on FIG. **4**. CCP **450** comprises interface **460**, translator **470** operably connected to interface **460**, processor **480** operably connected to translator **470**, and memory **490** operably connected to processor **480**.

CCP **450** functions to physically connect incoming links from other devices such as STPs, switches, SCPs, and operational control systems. Interface **460** is functional to accept the signals off of these links and transfer the signals to translator **470**. Interface **460** is also be able to transfer signaling from translator **470** to the links for transmission.

Translator **470** accepts the signaling from interface **460** and identifies the information in the signaling. Often, this will be done by identifying a known field within a given signaling message. For example, translator **470** might identify the Origination Point Code (OPC), Destination Point Code (DPC), and Circuit Identification Code (CIC) in an SS7 message. Additionally, translator **470** must be able to formulate outgoing signaling and transmit it to interface **460** for transmission. For example, translator **470** might replace the OPC, DPC, and CIC in a given SS7 message and transfer the modified SS7 message to interface **460** for transmission. Translator **510** must be equipped to manage the signaling formats it will encounter. Examples are SS7 and C7.

Processor **480** accepts the signaling information from translator **470** and makes the selections that accomplish communication control. This includes the selection of the network elements and/or connections that make the communications path. Typically, selections are made through table look-ups and SCP queries. Tables are entered and queries are generated based in part on the information identified by translator **470**. The table look-ups and SCP information retrieval yield new signaling information. The new information is transferred to translator **470** for formulation into appropriate signals for transmission. Algorithm solution could also be used to make selections. Processor **480** also handles various, status messages and alarms from the switches and other network elements. Operational control can also be accepted. This information can be used to modify the look-up tables or selection algorithms. Memory **490** is used by processor **480** to store programming, information, and tables.

FIG. **5** shows a flow diagram for the CCP for a version of the present invention. The sequence begins with the CCP receiving different types of information. Box **500** depicts the CCP accepting a signal from a first point. This signal could be in any format, such as SS7 or broadband signaling. The signal may have passed through STPs from a LEC over a signaling link, or it may also be a signal directly provided by an individual user of a network. The signal contains information about the requested communication path. An

example of such information is the message type which indicates the purpose of the message. Another example of such information is set-up information such as transit network service value, bearer capability, nature of address, calling party category, address presentation restriction status, carrier selection value, charge number, and originating line information, and service code value. Other information might be a network indicator or a service indicator. Those skilled in the art are familiar with these types of information.

Other types of information might also be accessed by the CCP. The network elements, such as switches, may provide the CCP with information as shown inbox **505**. This information allows the CCP to select network elements and connections based on network conditions. Examples of possible types of such information could be management messages, loading, error conditions, alarms, or idle circuits. The CCP might also provide the network elements with information.

Box **510** shows that operational control might be provided. Operational control allows system personnel to program the CCP. An example of such control might be to implement a management decision to retire a particular network element. Operational control would allow the removal that element from the selection process.

The CCP processes the information is has received in box **515**. Processing also entails the use of programmed instructions in the CCP, and might even include the use of information retrieved from a remote database, such as an SCP. The selections are then made as shown in box **520**. These selections specify network characteristics, such as network elements and/or connections. As stated above, The CCP may only select a portion of the network characteristics and allow the points or the switches to select the remainder. It should be pointed out that the information used in processing is not limited to that which is listed, and those skilled in the art will recognize other useful information which may be sent to the CCP.

Once network characteristics are selected, the CCP will signal the points and the applicable network elements of the selections. In box **525**, signals are formulated instructing the network elements of the network characteristics selected. The signals are transmitted to the appropriate network elements in box **535** which will typically result in a communication path through the network elements and connections. Other activity, such as applications and control procedures might be implemented as well. Additionally, in boxes **530** and **540**, signals are formulated and sent to the points. Typically the new signals generated by the CCP are sent to network elements or multiple signaling points. These new signals could be the same, however different signaling is typically sent to the different network elements which may used as part of a communication path.

FIG. **5** represents the sequence that the CCP performs in one embodiment to control communications and establish a communication path from a first point to a second point through network elements and connections. FIGS. **6** and **7** represent a similar sequence, and they are in the context of an Interexchange Carrier (IXC) similar to that depicted in FIG. **3**. The IXC accepts DS0 connections and SS7 signaling from a LEC and employs a broadband system to make the substantial portion of the communication path.

FIG. **6** depicts the flow of the CCP in a version of the present invention when a communication path is established from the LEC to a narrowband switch in the IXC. Box **600** shows that an SS7 message is accepted from the LEC which contains a Message Transfer Part (MTP) and an Integrated Service User Part (ISUP). As those skilled in the art are aware, the MTP contains the Originating Point Code (OPC) and the Destination Point Code (DPC). These point codes define specific signaling points in the network and are typically associated with a switch. As such, the OPC and DPC define a portion of the desired communication path.

When the communication path is extended into the IXC network, the OPC designates the LEC switch that connected to the IXC (**#325** on FIG. **3**). Previously, the DPC has designated the narrowband switch that the LEC would connect to for calls into the IXC. In this embodiment of the present invention, the DPC may designate a particular narrowband switch from the LEC's perspective, but the CCP actually selects the actual narrowband switch used. A mux or a broadband switch accepts the connection from the LEC, not a narrowband switch.

The ISUP contains the Circuit Identification Code (CIC) which designates the DS0 port that the LEC has seized. Previously, this DS0 Port was on a narrowband switch, but in this embodiment of the present invention, the DS0 port is actually on a mux.

Box **605** shows that the CCP may receive status information from the narrowband switches. These messages include Operational Measurements (OM) and CPU Occupancy information. OM includes trunk usage status of the switches which tells the CCP which DS0 ports are available on the narrowband switches. CPU Occupancy tells the CCP of the specific switching load of each narrowband switch. Box **610** shows that the CCP may also accept status information from the broadband switches indicating which connections are idle. This information allows the CCP to specify and balance routing through the broadband switches if desired. As discussed in relation to some of the other embodiments, the broadband switches may be left with that selection.

The CCP processes the information it has received in box **615**. Those skilled in the art are aware of other information which would be useful in this context. As a result of the processing, a narrowband switch and a DS0 port on that switch are typically selected as shown in box **620**. The selected narrowband switch may be close to the LEC or across the broadband network. The CCP determines which narrowband switch will process the call. This makes the narrowband switches virtually interchangeable.

Box **625** shows that a signal indicating these selections is generated and sent to the appropriate broadband switches in box **635**. As discussed, the broadband switches may employ interworking units to handle signaling. Typically, the broadband switches will use internal tables to select broadband connections based on information in the signal from the CCP. Such information might identify the existing extent of the communication path and specify the narrowband switch and the DS0 port on that switch to which the communication path should be extended. The tables would be entered with this information and yield a particular broadband connection to use. Broadband switches further along the communications path could also receive similar signals from the CCP and use similar tables. Alternatively, the broadband switches further along the communications path might only need to enter an internal table using the incoming broadband connection and yield a new broadband connection on which to extend the communications path.

Those skilled in the art are familiar with broadband systems which can accomplish this. Broadband signaling is discussed in the following ITU-TS Recommendations:

Q.2762 "B-ISDN, B-ISDN User Part—General Functions of Messages"; Q.2763 "B-ISDN, B-ISDN User Part—Formats and Codes"; Q.2764 "B-ISDN, B-ISDN User Part—Basic Call Procedures"; Q.2730 "B-ISDN, B-ISDN User Part—Supplementary Services"; Q.2750 "B-ISDN, B-ISDN User Part to DSS2 Interworking Procedures"; and Q.2610 "Usage of Cause and Location in B-ISDN User Part and DSS2".

In at least one embodiment, the broadband switches are equipped with signaling interworking units. These units translate SS7 messages into B-ISDN messages. In that event, the CCP could transmit SS7 to the broadband switches which could convert the signals properly. Interworking is discussed in ITU-TS Recommendation Q.2660, "B-ISDN, B-ISUP to N-ISUP Interworking".

In one embodiment, the broadband switches may select the actual virtual connection that corresponds through a mux to a DS0 port. This DS0 port could be on a narrowband switch or a on a point, such as a LEC switch. In this case, the CCP would not need to select a DS0 port since the broadband switch was in effect doing so. The internal tables of the broadband switches would be programmed to trigger when the particular broadband switch was connecting to particular broadband connections. These connections might be to a DS0 port on a narrowband switch or any specified point. Upon the trigger, the broadband switch would signal the CCP of the broadband connection it has used. The CCP would incorporate this information into the signal it sends to the narrowband switch or specified point. It is preferred that the CCP select the DS0 port on the selected narrowband switches, and that the broadband switches be allowed to select the broadband connection out of the network (through a mux) and signal the CCP of its selection.

The SS7 message from the LEC informed the CCP which DS0 port had been seized (the CIC), on which IXC device (DPC), and by which LEC switch (the OPC). By tracking the DS0 Port through the mux (#**380** on FIG. **3**), the CCP knows which connection the communication path will use to get to the broadband switch (#**360** on FIG. **3**). The CCP provides the broadband network with the proper signaling to extend the communication path from this switch to the selected narrowband switch as shown in box **635**.

Box **630** shows that the CCP formulates an SS7 message based on the selections relating to the narrowband switch. SS7 message formulation methods, such as drop and insert, are known in the art. A new DPC is inserted that will designate the narrowband switch selected by the CCP. A new CIC is inserted that will designate the DS0 port on that switch as selected by the CCP. The SS7 message is sent to the narrowband switch in box **640**.

As such, the communication path is extended from the LEC through the broadband network to the narrow band switch and the narrowband switch is notified of the incoming communication path. Another portion of the SS7 message contains call information including ANI and DNIS. This information was supplied by the LEC and is in the SS7 message sent to the narrowband switch.

The narrowband switch uses this information along with its own programming to switch the call. This switching may include various switching programs and remote databases. The narrowband switch will select a new DPC based on this processing. It will switch the call to a new DS0 port. Previously, this port was connected to a trunk connected to the next narrowband switch in the call routing scenario. However, in the present invention, the DS0 port is connected through a mux to broadband switch. The narrowband switch will place the new DPC in an SS7 message. Along with the new DPC, a new CIC identifying the new DS0 circuit, and a new OPC designating the narrowband switch itself is placed in the SS7 message and sent to the CCP.

FIG. **7** shows the flow of the CCP when extending a communication path from the selected narrowband switch to a point outside of the IXC in one embodiment of the present invention. The SS7 message generated by the narrowband switch after processing the call is received by the CCP in box **700**. In it, the CIC designates the DS0 port the communications path extends from on the narrowband switch. Because this port is connected to a mux with corresponding connections, the CCP can determine which connection the communication path uses to extend back to the broadband switch.

The CCP may also receive status information from the broadband switches as shown in box **705**. This information allows the CCP to select broadband connections if desired. As discussed, the broadband switches may make these selections. Typically, the broadband switches will use internal tables to select broadband connections based on information in the signal from the CCP. Such information might specify destination code. The destination code might correspond to a terminating switch or a LEC switch to which the communication path should be extended.

As shown in box **710**, the CCP applies processing and selects the appropriate destination for the broadband network to extend the communication path to as shown in box **715**. The CCP may use the new DPC provided by the narrowband switch to identify the destination for the broadband communication path.

In box **720**, signals. are generated reflecting this selection and sent to the appropriate broadband switches in box **725**. As discussed, the broadband switch may trigger and signal the CCP when it uses particular connections. This would occur for a connection through a mux to a LEC switch. This signal is accepted by the CCP in box **730** and is used to identify the DS0 port. An SS7 message is formulated in box **735** and in it the CIC will identify this DS0 connection on the LEC switch (#**335** on FIG. **3**). Alternatively, this DS0 port may have been selected by the CCP and signalled to the broadband switch. The LEC is signalled in box **740**

From FIGS. **6** and **7**, a sequence is shown that demonstrates the procedures that the CCP can follow to accept signaling from the LEC and make selections that control communications through the IXC network. The CCP must produce signals to implement its selections and transmit them to the applicable network elements. The CCP is able to use the outing, billing, and service features of a narrowband switch, but is still is able to employ a broadband network to make a substantial part of the communications path.

FIG. **8** is a flow diagram of CCP signal processing in one embodiment of the invention. Box **800** shows that an SS7 signal has been accepted by the CCP. Box **805** shows that the CCP determines the message type. If the message is not a call message, it is routed or used to update the CCP memory if appropriate as shown in box **810**. Non-call messages are familiar to those skilled in the art with examples being filler or management messages. If the SS7 message is a call message, it is examined to determine if it is an initial address message (IAM) in box **815**. Call messages and IAMs are familiar to those skilled in the art. If it is an IAM, the information provided by automatic number identification (ANI) is used to validate the call in box **820**. ANI validation is accomplished with a table look-up and is well known. If invalid, the communication path is terminated as shown in box **825**.

Once an IAM with a valid ANI is determined, a table is entered which yields an OPC—DPC—CIC combination as shown in box **830**. One skilled in the art will recognize that such a table can take many forms. One example is to set up a table with every combination of OPC—DPC—CIC on one side. The table is entered using OPC—DPC—CIC of the incoming IAM message. After entry through these fields is accomplished, the table yields a new OPC—DPC—CIC which can be formulated into the SS7 message and sent to the switching network as shown in box **835**. The switching network is capable of using this information to make connections.

Once the IAM signal has been processed, subsequent SS7 messaging, can be processed by a separate CIC look-up table entered using the CIC as shown in box **840**. Subsequent messages, such as address complete, answer, release, and release complete can be processed by entering the CIC table using the CIC in these non-IAM signals. For signals directed to the first point, the table yields the original OPC which is used as the DPC. Additionally, subsequent. messages from the first point enter the CIC table using their CIC, and the table yields the DPC previously selected by the CCP for the IAM processing. The CIC table is constantly updated to reflect current processing as shown in box **845**. In this way, the CCP is able to efficiently process non-IAMs because theses signals only need to reflect the results of previous IAM selections.

There can be exceptions to the use of the ClC table for non-IAM call messages. One example would be if a new connection is allowed after release. In that case, the IAM procedures would be followed.

Those skilled in the art will recognize the numerous factors that can be used to design and load the tables. Different OPC—DPC—CIC combinations can be yielded by the tables based on many factors. Some of these factors are: called number, time of day, CPU occupancy, switch status, trunk status, automatic call distribution, operational control, error conditions, network alarms, user requests, and network element status.

For example, if a certain switch must be taken out of service, it is merely replaced in the table with suitable substitutes. The switch is then effectively taken out of service because it is no longer selected. If the CPU loading of a certain switch reaches a threshold, its presence in the tables can be diminished and distributed to other switches.

In another example, if it is busy hour in region A, the tables may yield network elements in region B to process the call. This can be accomplished by adding an area code or a dialed number entry, and time of day entry in the table. For calls placed from an OPC in region A to an area code or dialed number in region B, a narrowband switch in region B could be selected. As such, the DPC yielded by the table during this time frame should reflect a region B narrowband switch. Also, for calls placed from an OPC in region B to an area code or dialed number in region A, the tables should provide the DPC of a region B narrowband switch.

In a preferred embodiment, IAM messages would cause the CCP to query an SCP, data element, or database for support. The SCP would answer the query by using tables as discussed above. The answers would be sent to the CCP and used to formulate signaling. Subsequent messages would be then handled by the CCP using the CIC table. An example of such support would be for the CCP to query the SCP in response to receiving an IAM message. The query may include the OPC, CIC, DPC, and the area code, or dialed number. The SCP could use this information to select network characteristics and avoid busy regions as described in the above busy region example. For example, the SCP would maintain tables for OPC—dialed area code—time of day combinations that would yield a new DPC and CIC. This assumes that busy hour in a region corresponds to time of day, but other factors and yields could also be involved.

In one embodiment, the dialed number or area code could be used to select the new DPC, and time stamps could be placed in the signaling. This might entail tables with OPC—dialed area code entries that yield a new DPC and CIC. In this case, narrowband switches may not even be needed since billing can be applied using the time stamps. The CCP could then route the call directly using only the broadband network. This is especially relevant for POTS calls in which only an area code entry would need to be added to the tables.

As discussed above, often a connection will consist of two separate connection procedures. One connection procedure will be from the origination to a selected network element. The other connection procedure will be from the selected network element to the destination. Also it has been disclosed that the CCP could actually be discreet machines located regionally. In these cases, the CCP device processing the first connection procedure could be located in the origination region, and the CCP device that processes the second connection procedure could be located in the region of the selected network element.

The present invention offers the advantage of separating at least a portion of the communication control from the communication path. By examining and translating signaling independently of the communication path, multiple switches and network elements can be connected in the optimum way. Communications paths are no longer limited to only the connections the switches can control. Networks do not have to wait for standardization among signaling and interface protocols.

The present invention allows for the selection of network characteristics, such as network elements and connections, before switches process or apply the signaling. The switches are not required to have a capability either to make selections or to signal each other. The switches only make connections as directed by the CCP which signals in each switches own signaling format. Various criteria can be used for the selections in the CCP, such as time of day, load balancing, or invalid ANI. As such, the present invention allows for a smooth transition from narrowband to broadband networks. It also allows for the selection of network elements, such as servers and enhanced services platforms.

The present invention represents a fundamental and powerful departure from previous telecommunications technology. By separating the communications path from communication control, the CCP can utilize different networks, and network devices, intelligently. Previously telecommunications systems have been dependent on the switches to accomplish communication control. As such, telecommunications systems have had to wait for the switches to develop communication control before new technology could be implemented. Switches have always been required to physically make connections and provide control over which connections are required. Switch capabilities have not been able to keep up with all of the network possibilities available. The result is a limited system.

Switches have been given support in this dual task. SCPs, STPs, and adjunct processors provide support for communication control. However, these devices only support the switches communication control, and the switch remains essential to communication control. This dependence has created a bottleneck given the available network possibilities.

One advantage of the present invention is that it allows narrowband switches be used interchangeably in a narrowband/broadband hybrid network. Any narrowband switch may be taken out of service without re-routing traffic and changing routing logic in each switch. The CCP is simply programmed not to select the given narrowband switch for call processing. The CCP will route calls over the broadband network to another narrowband switch. This flexibility also allows the telecommunications network to easily transfer narrowband switch loads.

An important advantage of this system is that both the advantages of broadband and narrowband systems are utilized. The transmission capabilities of a broadband network are coupled with the narrowband network's ability to apply features. For example, the CCP can use the broadband network to substantially make the call connection from origination to destination. The CCP diverts the traffic to the. narrowband network for processing. The narrowband network can apply features, such as billing and routing. Once processed, the traffic is directed back to the broadband network for completion of the connection. The CCP can then use the routing information generated by the narrow band system to route the traffic through the broadband system to the destination. As a result, the telecommunications system does not have to develop a billing or "800" routing feature for its broadband network. This can be accomplished because the CCP allows both networks to work together intelligently.

Another advantage of the present invention is the elimination of a substantial percentage of the DS0 ports required on the existing narrowband switches. In the current architectures, narrowband switches are interconnected to each other. A substantial percentage of the switch ports are taken up by these connections. By eliminating the need for the switches to connect to each other, these ports can be eliminated. Each narrowband switch is only connected to the broadband system. This architecture requires fewer ports per switch. By load balancing with the CCP, the number of ports required on busy switches can be reduced. The architecture in the present invention does require additional broadband ports, but these can be added at a significant cost saving versus narrowband ports.

Additionally, the narrowband switches no longer signal each other since all signaling is directed to the CCP. This concentration accounts for a reduction in required signaling link ports. This reduction possibly could result in the elimination of STPs.

As mentioned above, an advantage of the present invention is its ability to treat narrowband switches, or groups of narrowband switches, interchangeably. The CCP can pick any narrowband switch to process a particular call. This allows the network to pull narrowband switches out of service without taking extreme measures. In turn, this simplifies the introduction of new services into the network. A switch can be pulled out of service simply by instructing the CCP to stop selecting it. The switch can be re-programmed and put back into service. Then the next switch can then be updated in the same manner until all of the switches are implementing the new service. Switches can also be easily pulled to test developing applications.

This narrowband switch flexibility also allows the CCP to balance switch loads through the network during peak times, or during mass calling events. This eliminates the need to implement complex and expensive load balancing features in the narrowband network. Instead of programming the several switches to balance among themselves, one command to the CCP can achieve this.

Another advantage is the reduction in call set-up time. Most large networks require that a call pass through more than two narrowband switches arranged in a hierarchical fashion. One large network employs a flat architecture in which all narrowband switches are interconnected, but this still requires that the call pass through two narrowband switches. In the present invention, only one narrowband switch is required for each call. The use of broadband switches to set-up and complete the call represents significant time savings.

What is claimed is:

1. A method of operating a processing system to control a packet communication system for a user communication, the method comprising:

receiving a signaling message for the user communication from a narrowband communication system into the processing system;

processing the signaling message to select a network code that identifies a network element to provide egress from the packet communication system for the user communication;

generating a control message indicating the network code;

transferring the control message from the processing system to the packet communication system

receiving the user communication in the packet communication system and using the network code to route the user communication through the packet communication system to the network element; and

transferring the user communication from the network element to provide egress from the packet communication system.

2. The method of claim **1** wherein processing the signaling message comprises processing an Initial Address Message (IAM).

3. The method of claim **1** wherein processing the signaling message comprises processing a Signaling System #7 (SS7) message.

4. The method of claim **1** wherein processing the signaling message comprises processing a Q.931 message.

5. The method of claim **1** wherein processing the signaling message comprises processing in-band signaling.

6. The method of claim **1** wherein processing the signaling message to select the network code comprises processing caller number information in the signaling message.

7. The method of claim **1** wherein processing the signaling message to select the network code comprises processing called number information in the signaling message.

8. The method of claim **1** wherein processing the signaling message to select the network code comprises processing a point code in the signaling message.

9. The method of claim **1** wherein processing the signaling message to select the network code comprises processing a circuit identification code in the signaling message.

10. The method of claim **1** wherein processing the signaling message to select the network code comprises generating and transferring a query to a service control point and receiving and processing a response from the service control point.

11. The method of claim **1** further comprising processing geographic information to select the network code.

12. The method of claim **1** further comprising processing load balancing information to select the network code.

13. The method of claim **1** further comprising processing time of day information to select the network code.

14. The method of claim **1** further comprising processing a network alarm to select the network code.

15. The method of claim **1** wherein the network code comprises a logical address of the network element.

16. The method of claim **1** further comprising processing the signaling message to select a DS0 connection to provide the egress from the packet communication system.

17. The method of claim **1** further comprising processing the signaling message to select a wireless connection to provide the egress from the packet communication system.

18. The method of claim **1** wherein the network element comprises a switch.

19. The method of claim **1** wherein the network element comprises a multiplexer.

20. The method of claim **1** wherein the network element comprises a server.

21. The method of claim **1** wherein the network element comprises a service platform.

22. The method of claim **1** wherein the user communication comprises voice.

23. The method of claim **1** wherein the processing system is external to any communication switches.

24. A method of operating a processing system to control a packet communication system for a user communication, the method comprising:

selecting a network code that identifies a network element to provide egress for the user communication from the packet communication system to a narrowband communication system;

generating a control message indicating the network code and transferring the control message from the processing system to the packet communication system; and

generating a signaling message for the user communication and transferring the signaling message from the processing system to the narrowband communication system;

receiving the user communication in the packet communication system and using the network code to route the user communication through the packet communication system to the network element; and

transferring the user communication from the network element to the narrowband communication system to provide egress from the the packet communication system.

25. The method of claim **24** wherein generating and transferring the signaling message comprises generating and transferring an Initial Address Message (IAM).

26. The method of claim **24** wherein generating and transferring the signaling message comprises generating and transferring a Signaling System #7 (SS7)message.

27. The method of claim **24** wherein generating and transferring the signaling message comprises generating and transferring a Q.931 message.

28. The method of claim **24** wherein generating and transferring the signaling message comprises generating and transferring in-band signaling.

29. The method of claim **24** wherein the network code comprises a logical address of the network element.

30. The method of claim **24** further comprising selecting a DS0 connection to provide the egress from the packet communication system and identifying the DS0 in the signaling message.

31. The method of claim **24** further comprising selecting a wireless connection to provide the egress from the packet communication system and identifying the wireless message in the signaling message.

32. The method of claim **24** wherein the network element comprises a switch.

33. The method of claim **24** wherein the network element comprises a multiplexer.

34. The method of claim **24** wherein the network element comprises a server.

35. The method of claim **24** wherein the network element comprises a service platform.

36. The method of claim **24** wherein the user communication comprises voice.

37. The method of claim **24** wherein the user communication comprises data.

38. The method of claim **24** wherein the processing system is external to any communication switches.

* * * * *

EXHIBIT C

US006463052B1

(12) **United States Patent**
Christie

(10) **Patent No.: US 6,463,052 B1**
(45) **Date of Patent: *Oct. 8, 2002**

(54) **METHOD, SYSTEM AND APPARATUS FOR TELECOMMUNICATIONS CONTROL**

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(*) Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/082,182**

(22) Filed: **May 20, 1998**

Related U.S. Application Data

(63) Continuation of application No. 08/568,551, filed on Dec. 7, 1995, now Pat. No. 5,825,780, which is a continuation of application No. 08/238,605, filed on May 5, 1994, now abandoned.

(51) **Int. Cl.**[7] **H04L 12/66**
(52) **U.S. Cl.** **370/352**; 379/234
(58) **Field of Search** 370/351–360, 370/384, 385, 377, 395, 396, 397, 398, 399, 400, 409, 410; 379/201, 207, 94, 220, 221, 112, 234

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,201,889 A	5/1980	Lawrence et al.
4,310,727 A	1/1982	Lawser
4,348,554 A	9/1982	Asmuth
4,453,247 A	6/1984	Suzuki et al.
4,554,659 A	11/1985	Blood et al.
4,565,903 A	1/1986	Riley

(List continued on next page.)

FOREIGN PATENT DOCUMENTS

AU	B-23853/92	3/1993
DE	4225203 A1	12/1992
EP	0403414 A2	12/1990

(List continued on next page.)

OTHER PUBLICATIONS

N/A, “Intelligent Network/2: A flexible framework for exchange services,” Bell Communications Research Exchange, vol. 3 (No. 3), (May 23, 1987).

(List continued on next page.)

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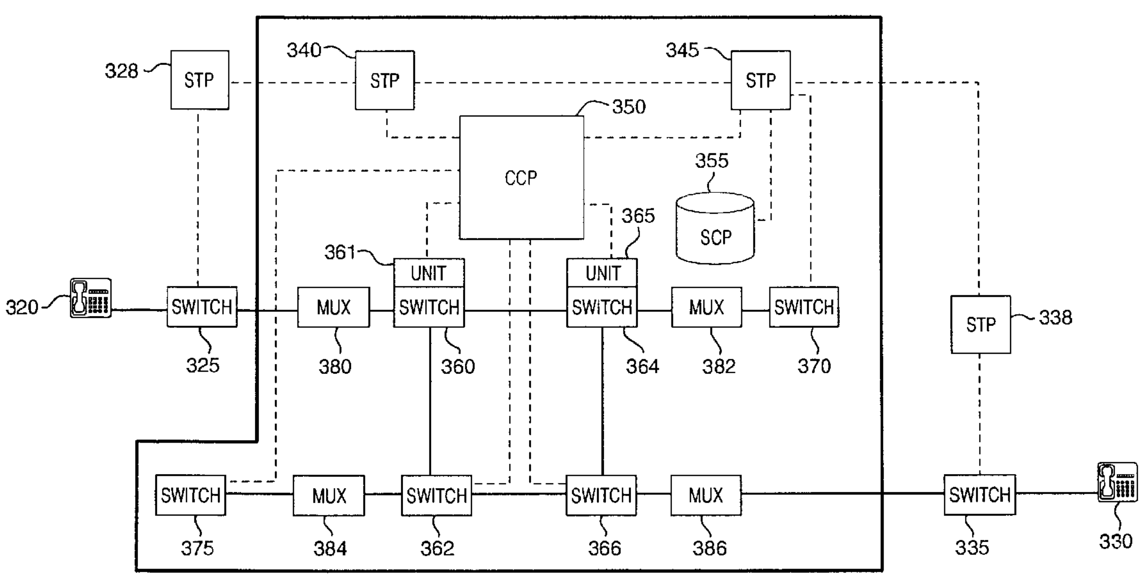
(57) **ABSTRACT**

The present invention includes a method, system, and apparatus for providing communication control. The invention includes a method in which signaling is processed externally to a switch before it is applied by the network elements. The processor is able to select network characteristics and signal the network elements based the selections. A network employing the processing method is also included, as well as a signaling system that employs the processing method.

24 Claims, 8 Drawing Sheets



U.S. PATENT DOCUMENTS

4,683,563	A		7/1987	Rouse et al.
4,720,850	A		1/1988	Oberlander et al.
4,730,312	A		3/1988	Johnson
4,736,364	A		4/1988	Basso et al.
4,748,658	A		5/1988	Gopal et al.
4,757,526	A		7/1988	Foster
4,763,317	A		8/1988	Lehman et al.
4,823,338	A		4/1989	Chan et al.
4,853,955	A		8/1989	Thorn et al.
4,895,319	A		1/1990	Lidinsky et al.
4,896,319	A		1/1990	Lidinsky et al.
4,916,690	A		4/1990	Barri
4,926,416	A		5/1990	Weik
4,979,118	A		12/1990	Kheradpir
4,985,889	A		1/1991	Frankish et al.
4,991,204	A		2/1991	Yamamoto et al.
4,993,014	A		2/1991	Gordon
4,993,104	A		2/1991	Gordon
5,003,584	A		3/1991	Benyacar et al.
5,018,191	A		5/1991	Catron et al.
5,036,318	A		7/1991	Bachhuber et al.
5,048,081	A		9/1991	Gavaras et al.
5,051,983	A		9/1991	Kammerl
5,058,104	A		10/1991	Yonehara et al.
5,067,123	A		11/1991	Hyodo et al.
5,073,890	A		12/1991	Danielsen
5,084,867	A		1/1992	Tachibana et al.
5,086,461	A		2/1992	Thorn et al.
5,089,954	A		2/1992	Rago
5,091,903	A		2/1992	Schrodi
5,101,404	A		3/1992	Kunimoto et al.
5,115,431	A		5/1992	Williams et al.
5,163,057	A		11/1992	Grupp
5,168,492	A		12/1992	Beshai et al.
5,179,556	A		1/1993	Turner
5,185,743	A		2/1993	Murayama et al.
5,193,110	A		3/1993	Jones et al.
5,204,857	A		4/1993	Obara
5,216,669	A		6/1993	Hofstetter et al.
5,218,602	A		6/1993	Grant et al.
5,231,631	A		7/1993	Buhrke et al.
5,231,633	A		7/1993	Hluchyi et al.
5,233,607	A		8/1993	Barwig et al.
5,239,539	A		8/1993	Uchida et al.
5,239,542	A		8/1993	Breidenstein et al.
5,249,178	A		9/1993	Kurano et al.
5,249,179	A		9/1993	Kurano et al.
5,251,255	A		10/1993	Epley
5,253,247	A		10/1993	Hirose et al.
5,255,266	A		10/1993	Watanabe et al.
5,258,752	A		11/1993	Fukaya et al.
5,258,979	A		11/1993	Oomuro et al.
5,268,895	A		12/1993	Topper
5,271,010	A		12/1993	Miyake et al.
5,274,680	A		12/1993	Sorton et al.
5,278,889	A	*	1/1994	Oapanicolaou et al. 379/53
5,282,244	A		1/1994	Fuller et al.
5,285,441	A		2/1994	Bansal et al.
5,289,472	A		2/1994	Cho
5,291,479	A		3/1994	Vaziri et al.
5,291,492	A		3/1994	Andrews et al.
5,311,509	A		5/1994	Heddes et al.
5,317,562	A		5/1994	Nardin et al.
5,323,389	A		6/1994	Bitz et al.
5,327,421	A		7/1994	Hiller et al.
5,327,433	A		7/1994	Hall
5,329,308	A	*	7/1994	Binns et al. 455/3.1
5,339,318	A		8/1994	Tanaka
5,339,818	A		8/1994	Tanaka et al.
5,345,443	A		9/1994	D'Ambrogio et al.
5,345,445	A		9/1994	Hiller et al.
5,345,446	A		9/1994	Hiller et al.
5,357,510	A		10/1994	Norizuki et al.
5,363,433	A		11/1994	Isono
5,365,524	A		11/1994	Hiller et al.
5,367,566	A		11/1994	Moe et al.
5,373,504	A		12/1994	Tanaka
5,375,124	A	*	12/1994	D'Ambrogio et al. 379/202
5,377,186	A		12/1994	Wegner et al.
5,384,771	A		1/1995	Isidoro et al.
5,384,840	A		1/1995	Blatchford et al.
5,392,402	A		2/1995	Robrock
5,394,393	A		2/1995	Brisson et al.
5,394,398	A		2/1995	Rau
5,400,339	A		3/1995	Sekine et al.
5,414,701	A		5/1995	Shtayer et al.
5,418,783	A		5/1995	Yamaki et al.
5,420,857	A		5/1995	Jurkevich
5,420,858	A		5/1995	Marshall et al.
5,420,916	A		5/1995	Sekiguchi
5,420,957	A		5/1995	Jurkevich
5,422,882	A		6/1995	Hiller et al.
5,425,090	A		6/1995	Orriss
5,426,636	A		6/1995	Hiller et al.
5,428,607	A		6/1995	Hiller et al.
5,428,609	A		6/1995	Eng et al.
5,434,852	A		7/1995	La Porta et al.
5,434,981	A		7/1995	Lenihan et al.
5,440,563	A		8/1995	Isidoro et al.
5,440,626	A		8/1995	Boyle et al.
5,444,713	A		8/1995	Backaus et al.
5,446,738	A		8/1995	Kim et al.
5,448,569	A		9/1995	Huang
5,452,296	A		9/1995	Shimizu
5,452,297	A		9/1995	Hiller et al.
5,453,981	A		9/1995	Katsube et al.
5,454,034	A		9/1995	Martin
5,457,684	A		10/1995	Bharucha
5,461,669	A		10/1995	Vilain
5,463,620	A		10/1995	Sriram
5,463,621	A		10/1995	Suzuki
5,473,677	A		12/1995	D'Amato et al.
5,473,679	A	*	12/1995	La Porta et al. 379/201
5,477,537	A		12/1995	Dankert et al.
5,479,401	A		12/1995	Bitz et al.
5,479,402	A		12/1995	Hata et al.
5,479,495	A		12/1995	Blumhardt
5,483,527	A		1/1996	Doshi et al.
5,485,455	A		1/1996	Dobbins et al.
5,490,251	A		2/1996	Clark et al.
5,495,484	A		2/1996	Self et al.
5,499,290	A		3/1996	Koster
5,504,742	A		4/1996	Kakuma et al.
5,506,844	A		4/1996	Rao
5,509,010	A		4/1996	La Porta et al.
5,509,123	A		4/1996	Dobbins et al.
5,513,178	A		4/1996	Tanaka
5,519,707	A		5/1996	Subramanian et al.
5,521,910	A		5/1996	Matthews
5,522,042	A		5/1996	Fee et al.
5,526,414	A		6/1996	Bedard et al.
5,530,698	A		6/1996	Kozaki et al.
5,533,106	A		7/1996	Blumhardt
5,539,815	A		7/1996	Samba
5,539,816	A		7/1996	Pinard et al.
5,539,884	A		7/1996	Robrock, II
5,541,918	A		7/1996	Ganmukhi et al.
5,541,926	A		7/1996	Saito et al.
5,544,152	A		8/1996	Obermanns et al.
5,544,161	A		8/1996	Bigham et al.
5,546,398	A		8/1996	Tucker et al.

5,548,580	A	8/1996	Buckland
5,550,819	A	8/1996	Duault
5,550,834	A	8/1996	D'Ambrogio et al.
5,550,914	A	8/1996	Clarke et al.
5,563,939	A	10/1996	La Porta et al.
5,566,173	A	10/1996	Steinbrecher
5,568,475	A	10/1996	Doshi
5,570,368	A	10/1996	Murakami et al.
5,572,583	A	11/1996	Wheeler, Jr. et al.
5,577,039	A	11/1996	Won et al.
5,579,311	A	11/1996	Chopping et al.
5,586,177	A	12/1996	Farris et al.
5,587,999	A	12/1996	Endo
5,592,477	A	1/1997	Farris et al.
5,600,640	A	2/1997	Blair et al.
5,600,643	A	2/1997	Robrock, II
5,627,836	A	5/1997	Conoscenti et al.
5,629,930	A	5/1997	Beshai et al.
5,635,980	A	6/1997	Lin et al.
5,636,210	A	6/1997	Agrawal
5,640,446	A	6/1997	Everett et al.
5,661,725	A	8/1997	Buck
5,666,349	A	9/1997	Petri
5,673,262	A	9/1997	Shimizu
5,680,390	A	10/1997	Robrock, II
5,703,876	A	12/1997	Christie
5,708,702	A	1/1998	DePaul et al.
5,710,769	A	1/1998	Anderson et al.
5,719,863	A	2/1998	Hummel
5,751,706	A	5/1998	Land
5,825,780	A	10/1998	Christie
6,016,343	A	1/2000	Hogan et al.

FOREIGN PATENT DOCUMENTS

EP	0443754	A3	2/1991
EP	0426911	A1	5/1991
EP	90312739.7		7/1991
EP	91303312.2		10/1991
EP	0460843	A2	12/1991
EP	0466078	A2	1/1992
EP	0482773	A1	4/1992
EP	91311342.9		7/1992
EP	0539016	A2	4/1993
EP	0549016	A1	6/1993
EP	92307752.3		9/1993
EP	0608584	A1	12/1993
EP	0582418	A2	2/1994
EP	0592152	A2	4/1994
EP	592153	A2	4/1994
EP	592154	A2	4/1994
FR	2616 025	A1	12/1988
HU	191 118		7/1985
JP	870284896		5/1989
JP	07050057		9/1996
SU	1579470	A	3/1979
WO	WO 94/06251		3/1991
WO	WO 92/14321		8/1992
WO	WO 93/18598		9/1993
WO	WO 94/05121		3/1994
WO	WO 94/28660		12/1994
WO	WO 95/04436		2/1995
WO	WO 95/08881		3/1995

OTHER PUBLICATIONS

N/A, "Communications for the Information Age," Globecom '88, Conference Record, (Nov. 28, 1988).

N/A, "Toward a Broadband Congestion Control Strategy," IEEE Network, The Magazine of Computer Communications, (May 23, 1990).

N/A, "Personal Communications Services and the Intelligent Network," British Telecommunications Engineering, (Aug. 23, 1990).

N/A, "Universal Service Creation and Provision Environment for Intelligent Network," IEEE Communications Magazine, (Jan. 23, 1991).

N/A, "Switching in a Competitive Market," IEEE Communications Magazine, (Jan. 23, 1991).

N/A, "Network Signaling," Telephony, TCX12004, University of Excellence, pp. 5.8–5.17, (Oct. 21, 1991).

Garrahan, J.J., et al., "Intelligent Network Overview," IEEE Communications Magazine, pp. 30–36, (Mar. 23, 1993).

Johnson, M.A., et al., "New Service Testing Functions for Advanced Intelligent Networks," IEEE 1992 Network Operations and Management Symposium, pp. 709–720, (Apr. 23, 1992).

Woodworth, Clark B., et al., "A Flexible Broadband Packet Switch for a Multimedia Integrated Network," International Conference on Communications, ICC–91, pp. 3.2.1–3.2.8, (Jun. 23, 1991).

Faynberg, I., et al., "The Support of Network Interworking and Distributed Context Switching in the IN Service Data Function Model," 2nd Colloque International, ICIN 92, pp. 11–16, (Mar. 23, 1992).

Minzer, Steven, "A Signaling Protocol for Complex Multimedia Services," IEEE Journal on Selected Areas in Communications (ISSN 0733–8716), vol. 9 (No. 9), pp. 1383–1394, (Dec. 23, 1991).

Fukazawa, M., et al., "Intelligent Network Call Model for Broadband ISDN," Fujitsu Laboratories Ltd. (Japan), pp. 30.6.1–30.6.5.

Ohta, S., et al., "A Dynamically Controllabel ATM Transport Network Based on the Virtual Path Concept," Communications for the Information Age, Globecom '88, Conference Record, pp. 1272–1276, (Nov. 28, 1988).

Yoshikai, N., et al., "General Arrangements For Interworking Between B–ISDN and 64kbit/s Based ISDN (Draft Recommendation I.580), Study Group 13," ITU–T Telecommunication Standardization Sector, pp. 1–51, (Mar. 7, 1994).

N/A, "Final Draft Text For Broadband Capability Set 2 Signalling Requirements, Study Group 11, Attachment "D" Special Drafting Meeting," ITU–T Telecommunication Standardization Sector, pp. 1–127, (Sep. 13, 1993).

Christie, Joseph M., "Broadband Telecommunications System," 08/525,897.

Christie, Joseph M., "System for Managing Telecommunications," 08/525,050.

N/A, "A Technical Report on Speech Packetization, Document T1A1/94—Prepared By T1A1.7, Working Group on Specialized Signal Processing."

McDysan, David E. and Spohn, Darren L., "ATM Theory and Application, ATM Layer VPI/VCI Level Addressing," p. 256: 9.3.1, (Apr. 23, 1994).

Minoli, Daniel, "Principles of Signaling for Cell Relay and Frame Relay," DVI Communications, Inc./Stevens Institute of Technology and Dobrowski, George/Bell Communications Research (Bellcore), pp. 1–2, 5–6, and 229, (Apr. 23, 1994).

Jordan, D.S., "Bell Operating Company Intelligent Voice Networks and Services, Proceedings of the National Communications Forum," Bell Communications Research, (Oct. 7, 1985).

N/A, "IN/B–ISDN Signalling Three Ways of Integration, Study Group 11," ITU–Telecommunication Standardization Sector, (Nov. 29, 1993).
N/A, "Interworking B–ISUP and Q.93B for DDI, MSN, TP and SUB, Study Group 11," ITU–Telecommunication Standardization Sector, (Nov. 29, 1993).
N/A, "Revised Draft of Q.2650 (DSS2/B ISUP) Interworking Recommendation, Study Group 11," ITU–Telecommunicaion Standardization Sector, (Nov. 29, 1993).
N/A, "Draft Broadband/Narrowband NNI Interworking Recommendation, Study Group 11," ITU—Telecommunication Standardization Sector, (Dec. 23, 1993).
N/A, "Draft Recommendation Q.2761, Study Group 11," ITU—Telecommunication Standardization Sector, (Nov. 29, 1993).
N/A, "Q.2931 Overview," ITU—Telecommunication Standardization Sector, p. 5.8–5.17, (Nov. 29, 1993).
N/A, "Clean final draft text for B–ISUP formats and codes (Q.2763) in ASN.1, Study Group 11," ITU—Telecommunication Standardization Sector, (Nov. 29, 1993).
N/A, "Updated draft of Q.2764 (BQ.764), Study Group 11," ITU—Telecommunication Standardization Sector, (Nov. 29, 1993).
N/A, "Final B–ISUP SDLs, Study Group 11," ITU—Telecommunication Standardization Sector, (Nov. 29, 1993).
N/A, "Draft Recommendation Q.2650, Study Group 11," ITU—Telecommunication Standardization Sector, (Nov. 29, 1993).
N/A, "Revised Draft of Q.2650 (DSS2/B–ISUP Interworking Recommendation), Study Group 11," ITU—Telecommunication Standardization Sector, (Nov. 29, 1993).
N/A, "Revision of Recommendation of Q.850," ITU–T SG 11 WP2, (Dec. 2, 1993).
N/A, "Draft Text for Q.2931 (CH. 1,2 and 3), Study Group 11," ITU—Telecommunication Standardization Sector, (Dec. 23, 1993).
N/A, "Q.2931, Clause 4—Information Elements," ITU—Telecommunication Standardization Sector, (Nov. 29, 1993).
N/A, "Section 5 of Q.93B, Study Group 11," ITU—Telecommunication Standardization Sector, (Nov. 29, 1993).
N/A, "Chapter 6 of Recommendation Q.93B, Study Group 11," ITU–Telecommunication Standardization Sector, (Nov. 29, 1993).
N/A, "Clauses 7 and 8 of Q.2931, Study Group 11," ITU–Telecommunication Standardization Sector, (Dec. 23, 1993).
N/A, "Revised Q.2931 User Side SDL Diagrams, Study Group 11," ITU–Telecommunication Standardization Sector, (Nov. 29, 1993).
N/A, "Revised Q.2931 Network Side SDL Diagrams, Study Group 11," ITU–Telecommunication Standardization Sector, (Nov. 29, 1993).
N/A, "Annexes B, C, D, F, H and I of Q.2931, Study Group 11," ITU–Telecommunication Standardization Sector, (Nov. 29, 1993).
N/A, "Annex E of Recommmendation Q.93B, Study Group 11," ITU–Telecommunication Standardization Sector, (Nov. 29, 1993).
N/A, "Rec. Q.2931, Annex G—Status Monitoring of SPCs, Study Group 11," ITU–Telecommunications Standardization Sector, (Nov. 29, 1993).
N/A, "Annex J of Q.2931, Study Group 11," ITU–Telecommunication Standardization Sector, (Dec. 23, 1993).
N/A, "Appendix 1/Q.2931: Guidelines for the Use of Instruction Indicators, Study Group 11," ITU–Telecommunication Standardization Sector, (Nov. 29, 1993).
N/A, "Draft text for Q.2931: Appendix II (Information Items Required for Connection Establishment and Routing in B–ISDN), Study Group 11," ITU–Telecommunication Standardization Sector.
N/A, "General Recommendations on Telephone Switching and Signalling—Intelligent Network/Distributed Functional Plane for Intelligent Network CS–1, ITU–T Recommendation Q.1214," ITU–Telecommunication Standardization Sector.
N/A, "Draft Recommendation Q.2762, Study Group 11," ITU–Telecommunication Standardization Sector, (Nov. 29, 1993).
Beckman, Richard T. and Matthews, Joseph R., "Proposal for a Physical Architecture Based on the Harmonized Functional Architecture," Committee T1 Contribution T1S1.5/95–027, Bellcore, (Feb. 20, 1995).
Yoshikai, N., et al., "Report of the Meeting of SWP 13/1–4 (Draft Recommendation I.580)," ITU–T Telecommunication Standardization Sector, Study Group 13, pp. 1–51, (Mar. 7–18, 1994).
N/A, "Final Draft Text for Broadband Capability Set 2 Signaling Requirements, Attachment "D" Special Drafting Meeting," ITU–T Telecommunications Standardization Sector, Study Group 11, p. 1–127, (Sep. 13–22, 1993).
Ohta, S., et al., "A Dynamically Controllable ATM Transport Network Based on the Virtual Path Concept," Communications for the Information Age, Globecom'88, Conference Record, p. 1272–1276, (Nov. 28–Dec. 1, 1988).
Fukazawa, M., et al., "Intelligent Network Call Model for Broadband ISDN," Fujitsu Laboratories, Ltd. (Japan), p. 30.6.1–30.6.5.
Minzer, Steven, "A Signaling Protocol for Complex Multimedia Services," IEEE Journal on Selected Areas in Communications (ISSN 0733–8716), vol. 9 (No. 9), p. 1383–1394, (Dec. 1991).
Faynberg, I., et al., "The Support of Network Interworking and Distributed Context Switching in the IN Service Data Function Model," 2nd Colloque International, ICIN 92, p. 11–16, (Mar. 1992).
Woodworth, Clark B., et al., "A Flexible Broadband Packet Switch for a Multimedia Integrated Network," International Conference on Communications, Denver, ICC–91, p. 3.2.1–3.2.8, (Jun. 1991).
Miller, P., "Intelligent Network/2: A flexible framework for exchange services," Bell Communications Research Exchange, vol. 3 (No. 3), (May/Jun. 1987).
Cooper, C., et al., "Toward a Broadband Congestion Control Strategy," IEEE Network, The Magazine of Computer Communications, (May 1990).
Batten, A., "Personal Communications Services and the Intelligent Network," British Telecommunications Engineering, (Aug. 1990).
Fujioka, M., et al., "Universal Service Creation and Provision Environment for Intelligent Network," IEEE Communication Magazine, (Jan. 1991).
Andrews, F., "Switching in a Competitive Market," IEEE Communications Magazine, (Jan. 1991).
N/A, "Network Signaling," Telephony, TCX12004, University of Excellence, p. 5.8–5.17, (Oct. 21, 1991).
Garrahan, J.J., et al., "Intelligent Network Overview," IEEE Communications Magazine, p. 30–36, (Mar. 1993).

Johnson, M.A., et al., "New Service Testing Functions for Advanced Intelligent Networks," IEEE 1992 Network Operations and Management Symposium, p. 709–720, (Apr. 6, 1992).
Yeh, S.Y., et al., "The Evolving Intelligent Network Architecture," IEEE Conference on Computer and Communication Systems, p. 835–839, (1990).
Atoui, M., "Virtual Private Network Call Processing in the Intelligent Network," International Conference on Communications, p. 561–565, (1992).
Bosco, P., et al., "A Laboratory for AIN Service Design and Validation," International Conference on Communications, p. 566–571, (Jun. 14, 1992).
Homa, J., et al., "Intelligent Network Requirements for Personal Communications Services," IEEE Communications Magazine, p. 70–76, (Feb. 1992).
Russo, E.G., et al., "Intelligent Network Platforms in the U.S.," AT&T Technical Journal, p. 26–43, (1991).
Van Den Broek, W., et al., "Race 2066–Functional models of UMTS and integration into the future networks," Electronics & Communications Engineering Journal, p. 165–172, (Jun. 1993).
Pinkham, G., et al., "The Ericsson Approach to Intelligent Networks," IEEE Global Telecommunications Conference & Exhibition, Session 10, paragraph 4, p. 320–324, (1988).
N/A, "ANSI–TI.111–1992, Signaling System No. 7 (SS7)—Message Transfer Part (MTP)," American National Standard for Telecommunications.
N/A, "ANSI–TI.112–1992, Signaling System No. 7 (SS7)—Signaling Connection Control Part (SCCP)," American National Standard for Telecommunications.
N/A, "ANSI–T1.113–1992, Signaling System No. 7 (SS7)—Integrated Services digital Network (ISDN) User Part," American National Standard for Telecommunications.
N/A, "ANSI–TI.113a–1993, Signaling System No. 7 (SS7)—Integrated Services Digital Network (ISDN) User Part (NxDSO Multi–rate Connection)," American National Standard for Telecommunications.
N/A, "ANSI–TI.113–1995, Signaling System No. 7 (SS7)—Integrated Services Digital Network (ISDN) User Part," American National Standard for Telecommunications.
N/A, "ATM at a Glance," Transmission Technologies Access Guide, p. 40–42, (1993).
Paglialunga, A., "ISCP Baseline Document (VER 3.1)," ITU Telecommunication Standardization Sector, Centre Studi E Laboratori Telecommunicazioni S.p.A., (1993).
N/A, "A Technical Report on Speech Packetization," Document T1A1/94—Prepared by T1A1.7, Working Group on Specialized Signal Processing.
N/A, "Draft Revised Recommendation I.580," ITU—Telecommunication Standardization Sector, Study Group 13, (Jul. 10–21, 1995).
Sprague, David, "MTP Level–3 Gateway STP Release 3.2.0," Tekelec, p. 1–48, (Aug. 4, 1995).
McDysan, David E. and Spohn, Darren L., "ATM Theory and Application," ATM Layer VPI/VCI Level Addressing, p. 256: 9.3.1, (1994).
Minoli, Daniel and Dobrowski, George, "Principles of Signaling for Cell Relay and Frame Relay," DVI Comm., Inc./Stevens Institute of Technology / Bell Comm. Research (Bellcore), p. 1–2, 5–6 and 229, (1994).
N/A, "B–IDSN ATM Adaptation Layer (AAL) Specification, Types 1 & 2," ITU Draft Recommendation I.363.1, (Jul. 21, 1995).
N/A, "Circuit Emulation Service Interoperability Specification Version 2.0 (Baseline Draft), 95–1504," The ATM Forum Technical Committee, (Dec. 1995).
N/A, "IN/B–ISDN Signalling Three Ways of Integration," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29–Dec. 17, 1993).
N/A, "Interworking B–ISUP and Q.93B for DDI, MSN, TP and SUB," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29–Dec. 17, 1993).
N/A, "Revised Draft of Q.2650 (DSS2/B–ISUP Interworking Recommendation)," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29—Dec. 17, 1993).
N/A, "Draft Broadband / Narrowband NNI interworking recommendation," ITU—Telecommunication Standardization Sector, Study Group 11, (Dec. 1993).
N/A, "Draft Recommendation Q.2761," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29—Dec. 17, 1993).
N/A, "Draft Recommendation Q.2762," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29—Dec. 17, 1993).
N/A, "Q.2931 Overview," ITU—Telecommunication Standardization Sector, (Nov. 29–Dec. 17, 1993).
N/A, "Clean final draft text for B–ISUP formats and codes (Q.2763) in ASN.1," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29–Dec. 17, 1993).
N/A, "Updated draft of Q.2764 (BQ.764)," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29–Dec. 17, 1993).
N/A, "Final B–ISUP SDLs," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29–Dec. 17, 1993).
N/A, "Draft Recommendation Q.2650," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29–Dec. 17, 1993).
N/A, "Revised Draft of Q.2650 (DSS2/B–ISUP Interworking Recommendation)," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29–Dec. 17, 1993).
N/A, "Revision of Recommendation of Q.850," ITU—T SG 11 WP2, (Dec. 2–15, 1993).
N/A, "Draft Text for Q.2931 (CH. 1, 2 and 3)," ITU—Telecommunication Standardization Sector, Study Group 11, (Dec. 1993).
N/A, "Q.2931, Clause 4—Information Elements," ITU—Telecommunication Standardization Sector, (Nov. 29–Dec. 17, 1993).
N/A, "Section 5 of Q.93B," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29–Dec. 17, 1993).
N/A, "Chapter 6 of Recommendation Q.93B," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29–Dec. 17, 1993).
N/A, "Clauses 7 and 8 of Q.2931," ITU—Telecommunication Standardization Sector, Study Group 11, (Dec. 1993).
N/A, "Revised Q.2931 User Side SDL Diagrams," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29–Dec. 17, 1993).
N/A, "Revised Q.2931 Network Side SDL Diagrams," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29–Dec. 17, 1993).

N/A, "AnnexesB, C, D, F, H and I of Q.2931," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29–Dec. 17, 1993).

N/A, "Annex E of Recommendation Q.93B," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29–Dec. 17, 1993).

N/A, "Rec. Q.2931, Annex G—Status Monitoring of SPCs," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29–Dec. 17, 1993).

N/A, "Annex J of Q.2931," ITU—Telecommunication Standardization Sector, Study Group 11, (Dec. 1993).

N/A, "Appendix 1/Q.2931: Guidelines for the Use of Instruction Indicators," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29–Dec. 17, 1993).

N/A, "Draft text for Q.2931: Appendix II (Information Items Required for Connection Establishment and Routing in B–ISDN)," ITU—Telecommunication Standardization Sector, Study Group 11.

N/A, "General Recommendations on Telephone Switching and Signalling—Intelligent Network / Distributed Functional Plane for Intelligent Network CS–1," ITU–T Recommendation Q.1214.

Kumar, Sanjay, "Legacy Voice Service at a Native ATM Terminal," ATM_Forum/95–091R1, ATM Forum Technical Committee, (Oct. 2–6, 1995).

Duault, Maurice, et al., "Baseline Text for Voice and Telephony Over ATM—ATM Trunking for Narrowband Services," ATM_Forum/95–0446R3, ATM Forum Technical Committee, (Oct. 2–6, 1995).

Choi, Don, "Requirements for ATM Trunking," ATM_Forum/95–1401, ATM Forum Technical Committee, (Oct. 2–6, 1995).

Chiang, Chin, "Proposed Changes to Proxy Signaling Capability," ATM Forum/95–0046, ATM Forum: Signaling Working Group, (Feb. 6–10, 1995).

Amin–Salehi, Bahman, "Third Party Call Setup for a Video–on Demand Connection Establishment," ATM_Forum/95–0022, ATM Forum Technical Committee, (Feb. 5–8, 1995).

Caves, Keith, "Proposed Modifications to the Baseline Text (95–0446R2) of the 'VTOA—ATM Trunking for Narrowband Services' Specification," ATM Forum/95–1134, ATM Forum Technical Committee, (Oct. 2–6, 1995).

Schink, Helmut, et al., "CES as a Flexible Trunking Method," ATM_Forum/95–1157, ATM Forum Technical Committee, (Oct. 2–6, 1995).

Duault, Maurice, "Proposal for ATM Trunking Options," ATM_Forum/95–1230, ATM Forum Technical Committee, (Oct. 2–6, 1995).

Okutani, Takenori, et al., "VTOA: Reference Configuration–ATM Trunking for Narrowband Services," ATM–Forum/95–1364, ATM Forum Technical Committee, (Oct. 2–6, 1995).

Stodola, Kevin, "Circuit Emulation Services Version 2 Baseline," ATM_Forum/95–1504, ATM Forum Technical Committee, (Dec. 11–15, 1995).

N/A, "I.751 Asynchronous Tranfer Mode (ATM) Management View of the Network Element View," ITU—Telecommunication Standardization Sector, Study Group 15, (Nov. 13–24, 1995).

N/A, "Draft I.732," ITU—Telecommunication Standardization Sector, Study Group 15, (Nov. 13–24, 1995).

N/A, "Editorial Modifications for Draft New ITU–T Recommendation I.731," ITU—Telecommunication Standardization Sector, Study Group 15, (Nov. 13–24, 1995).

Buhrke, R.E., "Proposed Unified Functional Model," T1S1.5/95–036, Committee T1 Contribution, (Feb. 1995).

Barr, W.J., et al., The TINA Initiative, IEEE Communications Magazine, vol. 31, No. 3, Mar. 1993, New York (US), pp. 70–76.

Chen, S., et al., Intelligent Networking For The Global Marketplace, IEEE Communications Magazine, vol. 31, No. 3, Mar. 1993, New York (US), pp. 86–92.

Fujioka, M., et al., Hierarchical And Distributed Information Handling For UPT, IEEE Network Magazine, Nov., 1990.

Gilmour, J., et al., Intelligent Network/2: The Architecture—The Technical Challenges—The Opportunities, IEEE Communications Magazine, vol. 26, No. 12, Dec. 1988, New York (US) pp. 8–11 and 63.

Weisser, F. J., et al., The Intelligent Network And Forward–Looking Technology, IEEE Communications Magazine, vol. 26, No. 12, Dec. 1988, New York (US), pp. 64–69.

General Recommendations On Telephone Switching And Signaling Intelligent Network—Intelligent Network Distributed Functional Plane Architecture, Q.1204, ITU–T—Mar. 1993.

General Recommendations On Telephone Switching And Signaling Intelligent Network–Intelligent Network Physical Plane Architecture Q.1205, ITU–T Recommendation, Telecommunication Standardization Sector of ITU.

Rec. I. 312, "ISDN—Principles Of Intelligent Network Architecture." ITU—Telecommunication Standardization Sector, Oct., 1992; Rec. Q. 1201, "Overall Network Aspects And Functions, ISDN User–Network Interfaces—Principles Of Intelligent Networks Architecture." ITU—Telecommunication Standardization Sector, Oct., 1992.

Rec. Q. 1200. "General Recommendations On Telephone Switching And Signaling—Intelligent Network—Q–Series Intelligent Network Recommendation Structure." ITU—Telecommunication Standardization Sector, Sep., 1997.

Yoshiaki, N., et al., "General Arrangements for Interworking Between B–ISDN and 64kbit/s Based ISDN (Draft Recommendation I.580), Study Group 13," ITU–T Telecommunication Standardization Sector, pp. 1–51, Mar. 7, 1994.

Rec. Q. 1218, "General Recommendations On Telephone Switching And Signaling—Intelligent Network—Interface Recommendation For Intelligent Network CS–1." ITU—Telecommunication Standardization Sector, Oct., 1995.

"General Recommendations On Telephone Switching And Signalling," ITU–T Recommendation Q.1214, ITU–Telecommunication Standardization Sector, Mar., 1993.

McKinney, Scott, "ATM for Narrowband Services" IEEE Communications Magazine, Apr., 1994, New York, US, pp. 64–72.

Tanabe, Shirou, "A New Distributed Switching System Architecture for B–ISDN" IEEE International Conference on Integrated Broadband Services and Networks, Oct. 15–18, 1990.

McDysan, David, "ATM Theory and Application," McGraw–Hill Series on Computer Communications.

David Giddy and Rob Palmer, An Experimental ATM Network Featuring De–Coupled Modular Control, Telecom Australia Research Laboratories, IEEE, 1992.

Rob Palmer, An Experimental ATM Network for B–ISDN Research, Telecommunications Research Laboratories of AOTC, IEEE, 1992.

Barry T. Dingle, ISDN Signalling control Part (ISCP), Australian Broadband Switching and Services Symposium, Melbourne Jul. 15–17, 1992.

S. L. Sutherland, Broadband ISDN Interworking, Australian Broadband Switching and Services Symposium, vol. 2, Melbourne Jul. 15–17, 1992.

* cited by examiner

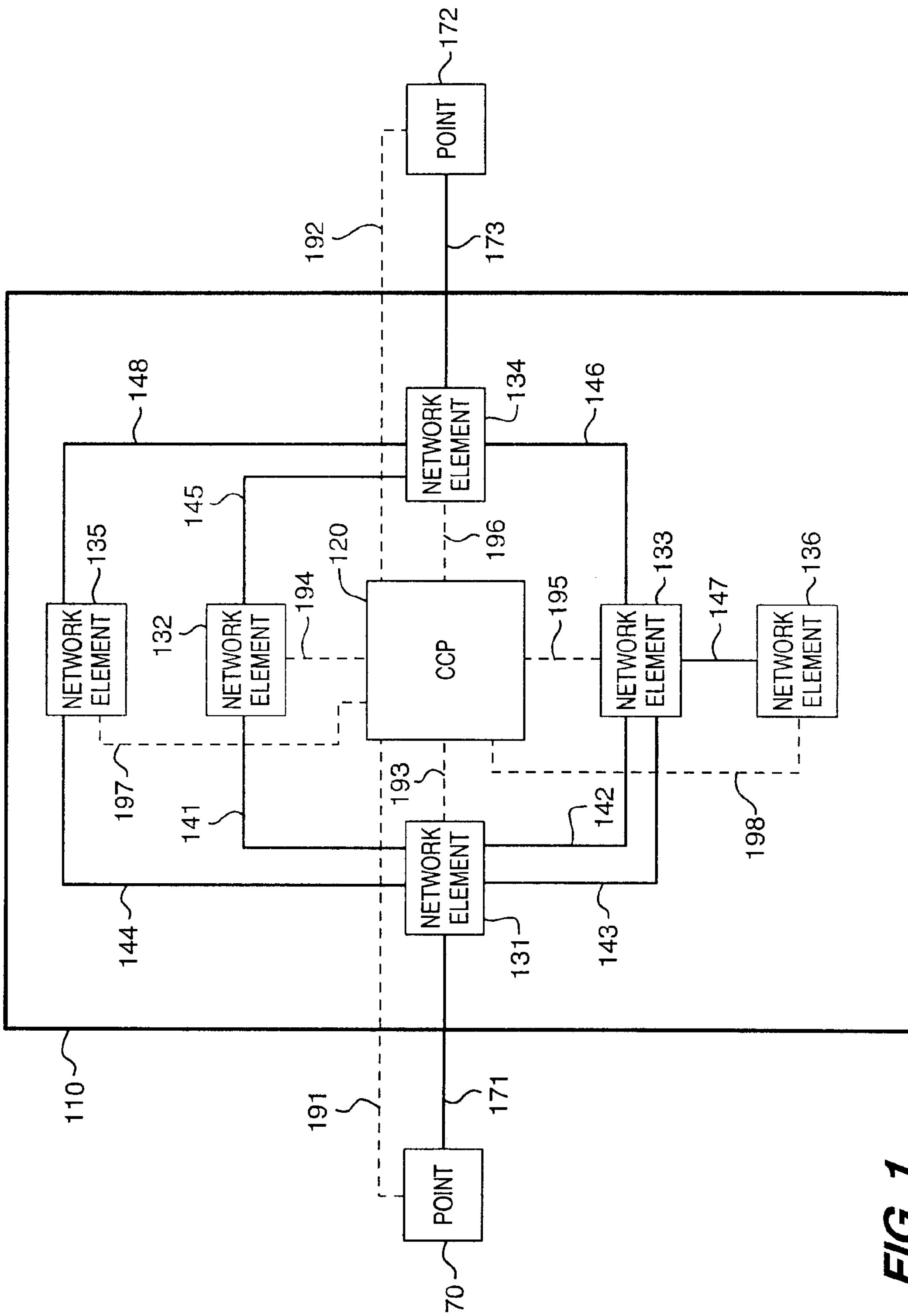
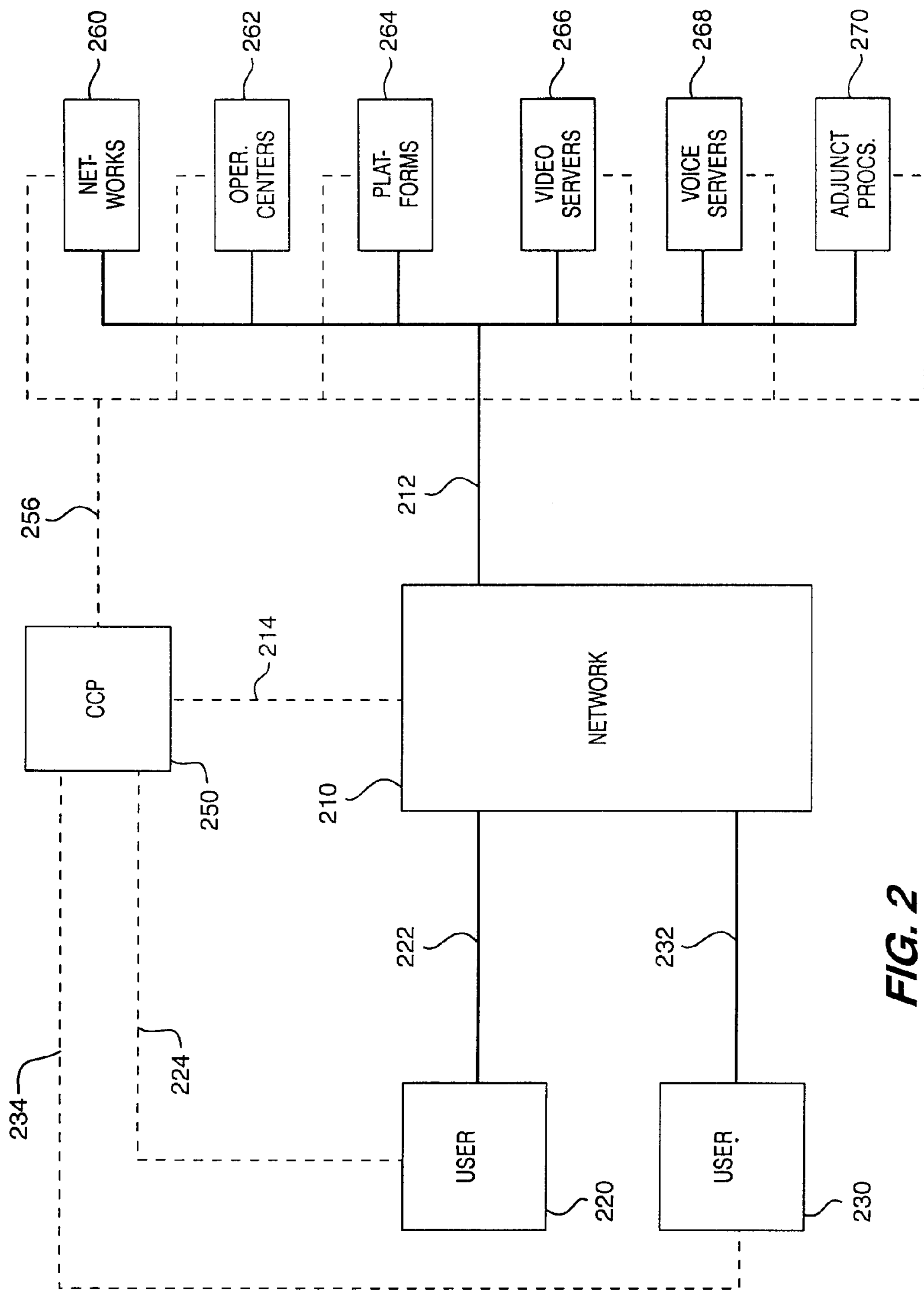

172
POINT
192
173
148
134
NETWORK ELEMENT
146
145
196
120
135
NETWORK ELEMENT
132
NETWORK ELEMENT
194
CCP
195
133
NETWORK ELEMENT
147
136
NETWORK ELEMENT
197
193
198
141
142
NETWORK ELEMENT
144
131
143
110
191
171
POINT
170

FIG. 1



260
NET-WORKS
262
OPER. CENTERS
264
PLAT-FORMS
266
VIDEO SERVERS
268
VOICE SERVERS
270
ADJUNCT PROCS.
256
212
214
CCP
250
NETWORK
210
222
232
224
234
USER
220
USER
230

FIG. 2

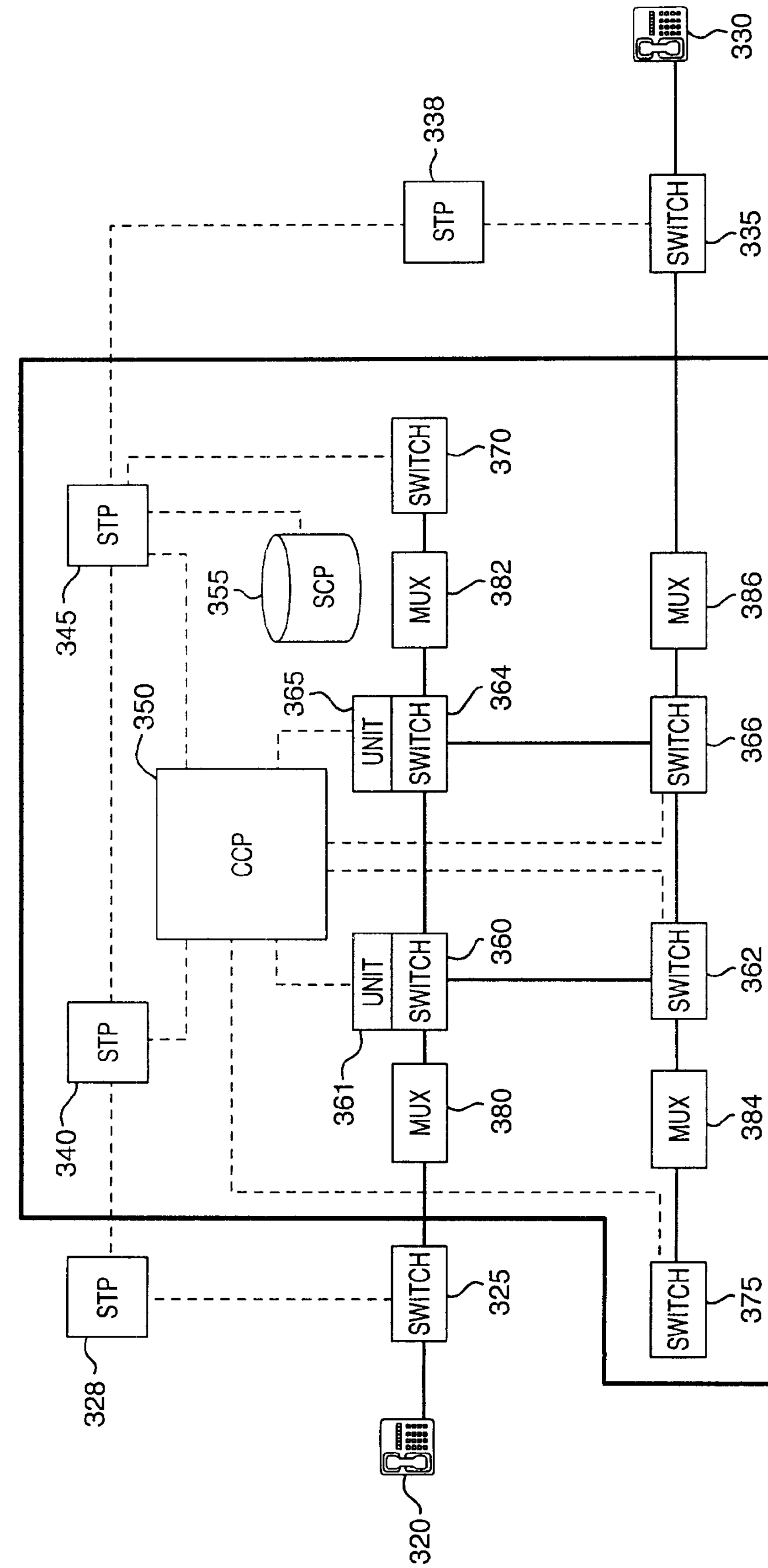

330
338
STP
SWITCH
335
STP
345
SWITCH
370
355
SCP
MUX
382
MUX
386
350
365
UNIT
SWITCH
364
SWITCH
366
CCP
UNIT
SWITCH
360
SWITCH
362
STP
340
361
MUX
380
MUX
384
STP
328
SWITCH
325
SWITCH
375
320

FIG. 3

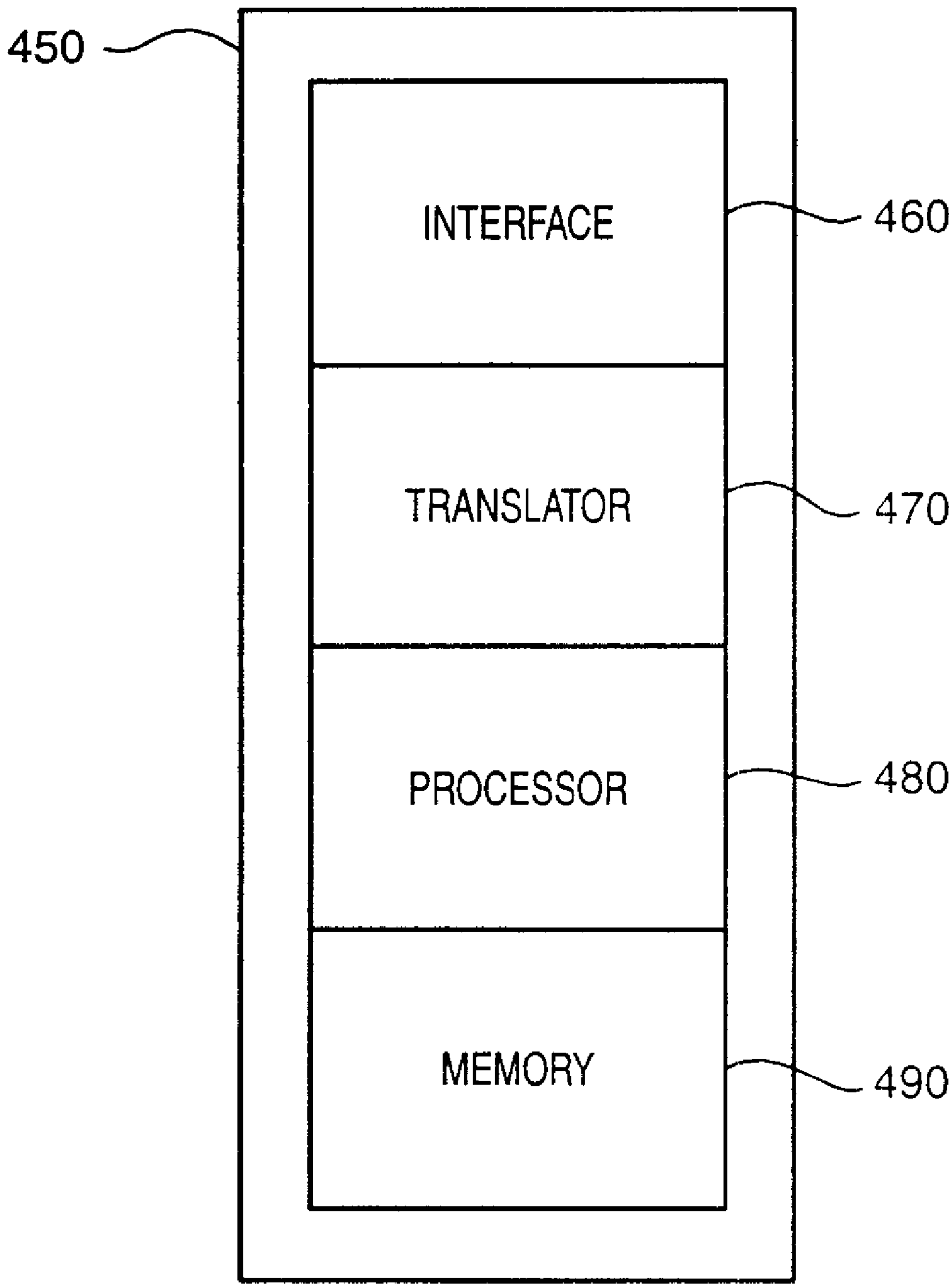


FIG. 4

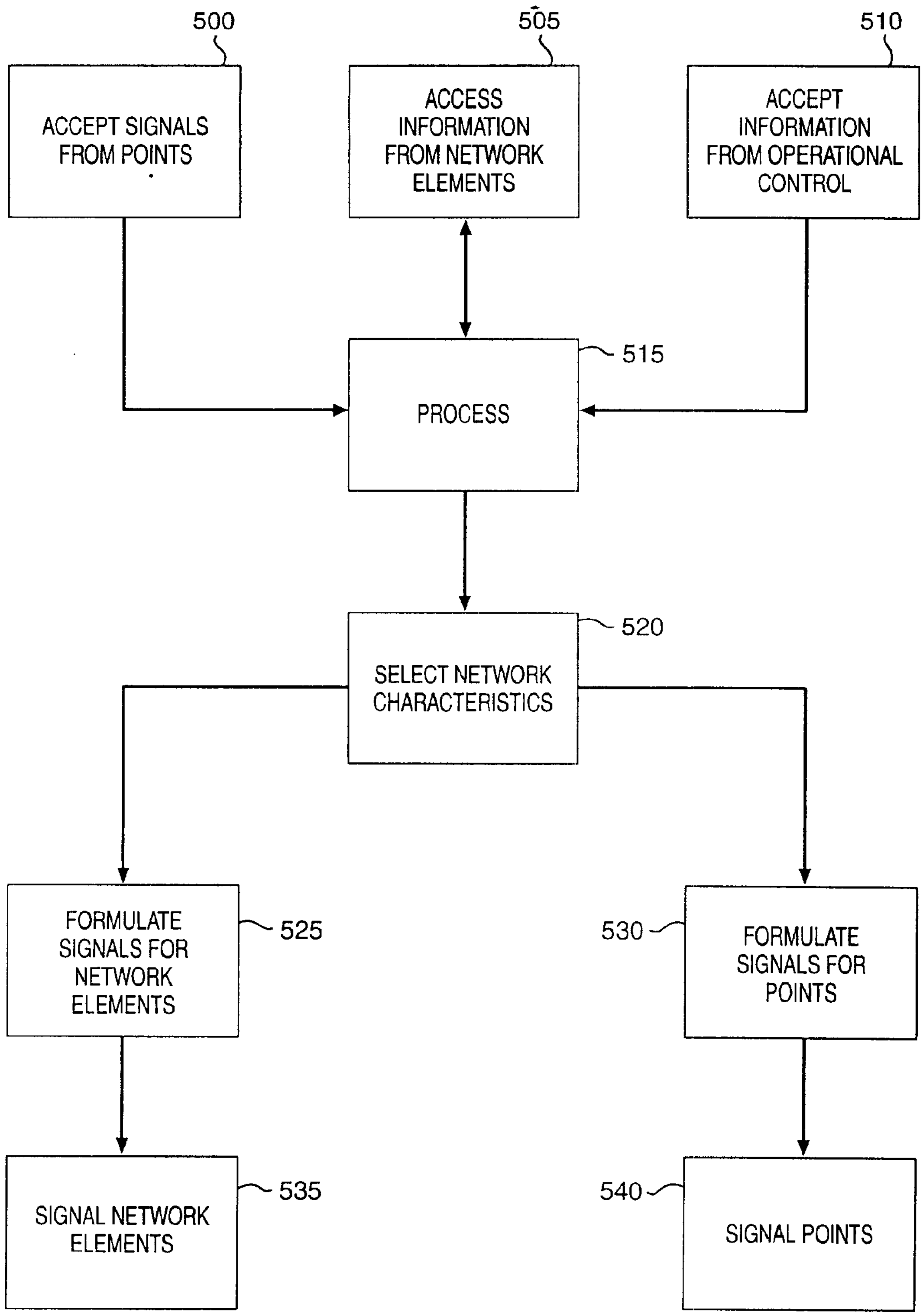

500
ACCEPT SIGNALS FROM POINTS
505
ACCESS INFORMATION FROM NETWORK ELEMENTS
510
ACCEPT INFORMATION FROM OPERATIONAL CONTROL
515
PROCESS
520
SELECT NETWORK CHARACTERISTICS
525
FORMULATE SIGNALS FOR NETWORK ELEMENTS
530
FORMULATE SIGNALS FOR POINTS
535
SIGNAL NETWORK ELEMENTS
540
SIGNAL POINTS

FIG. 5

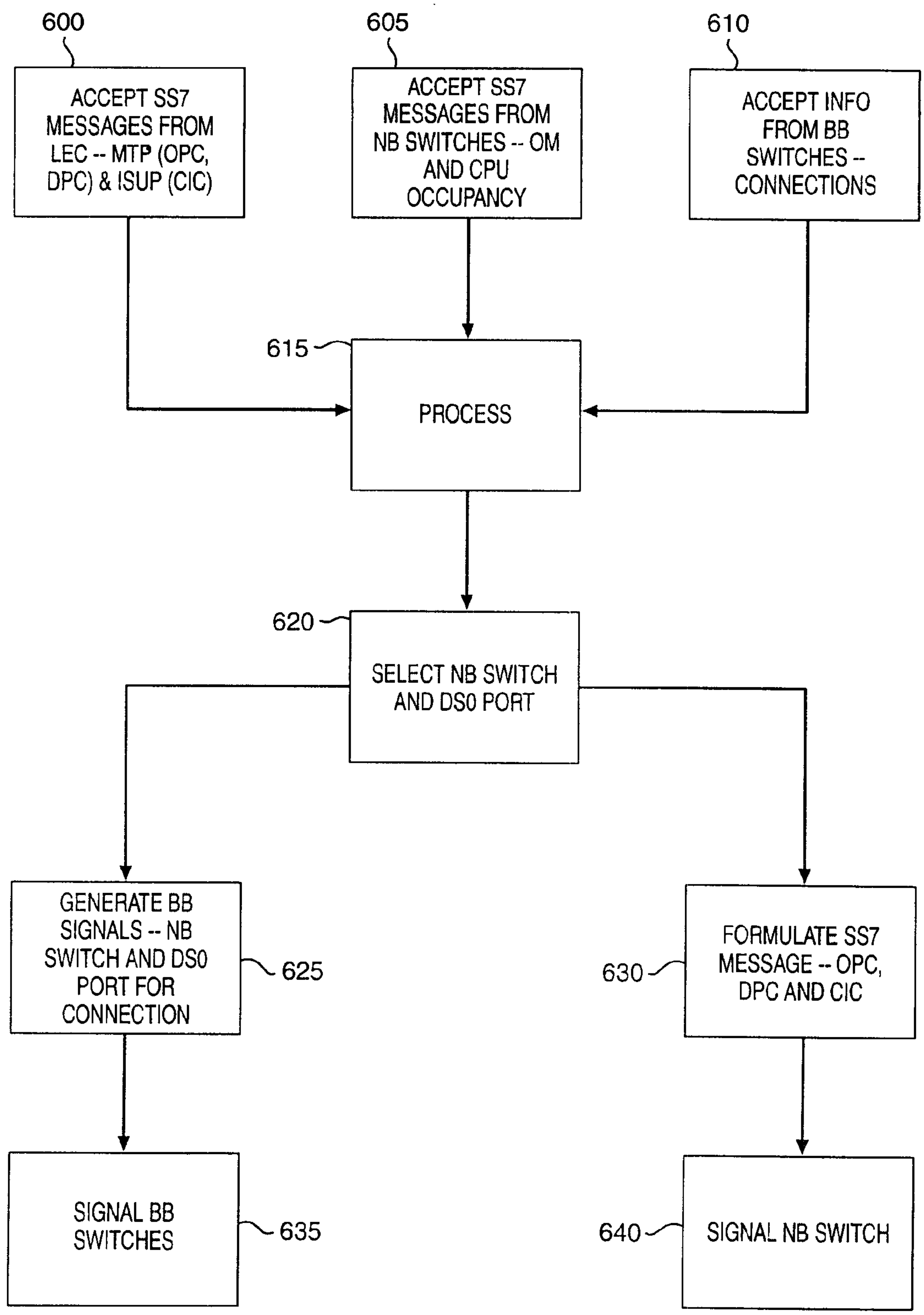
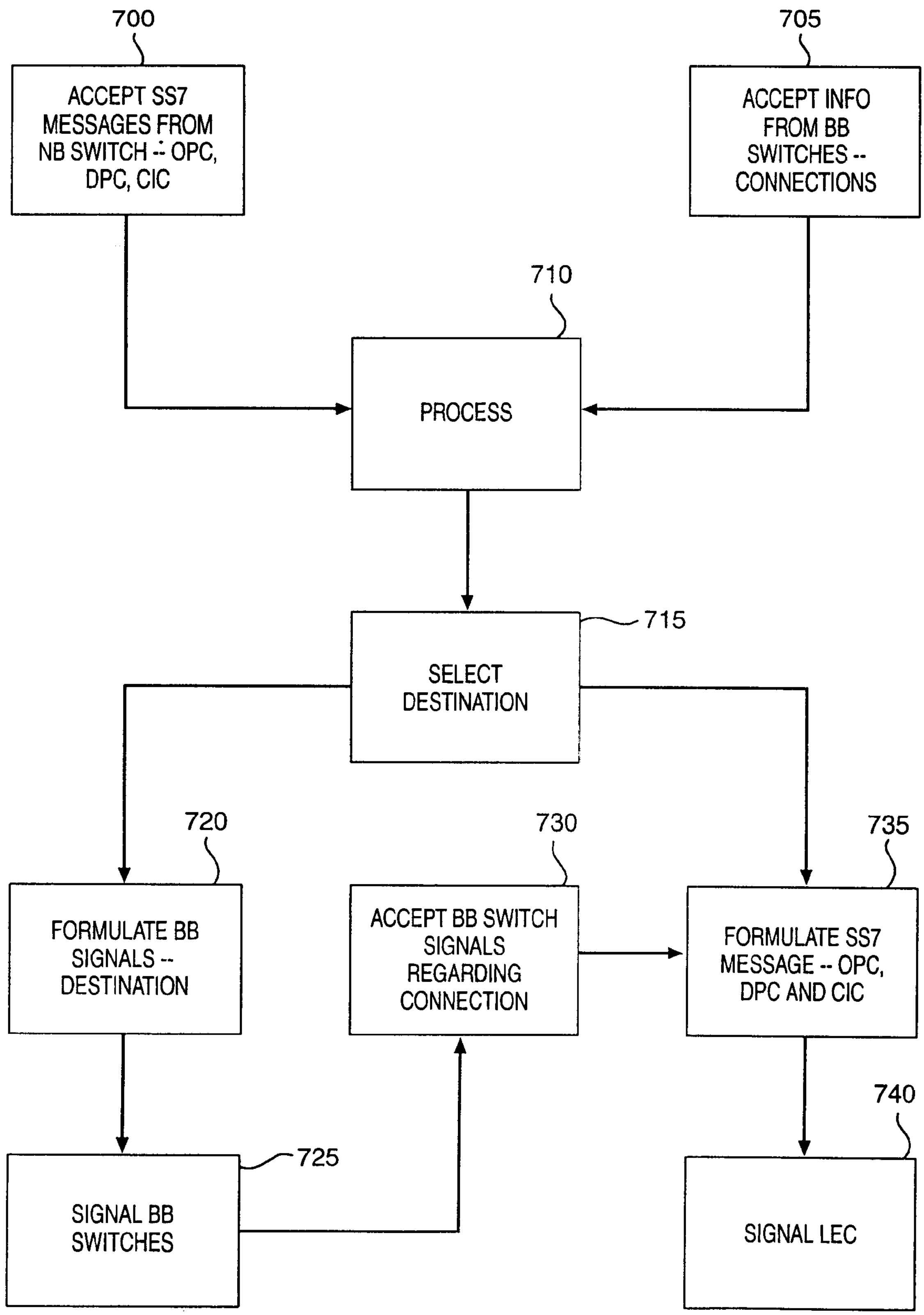
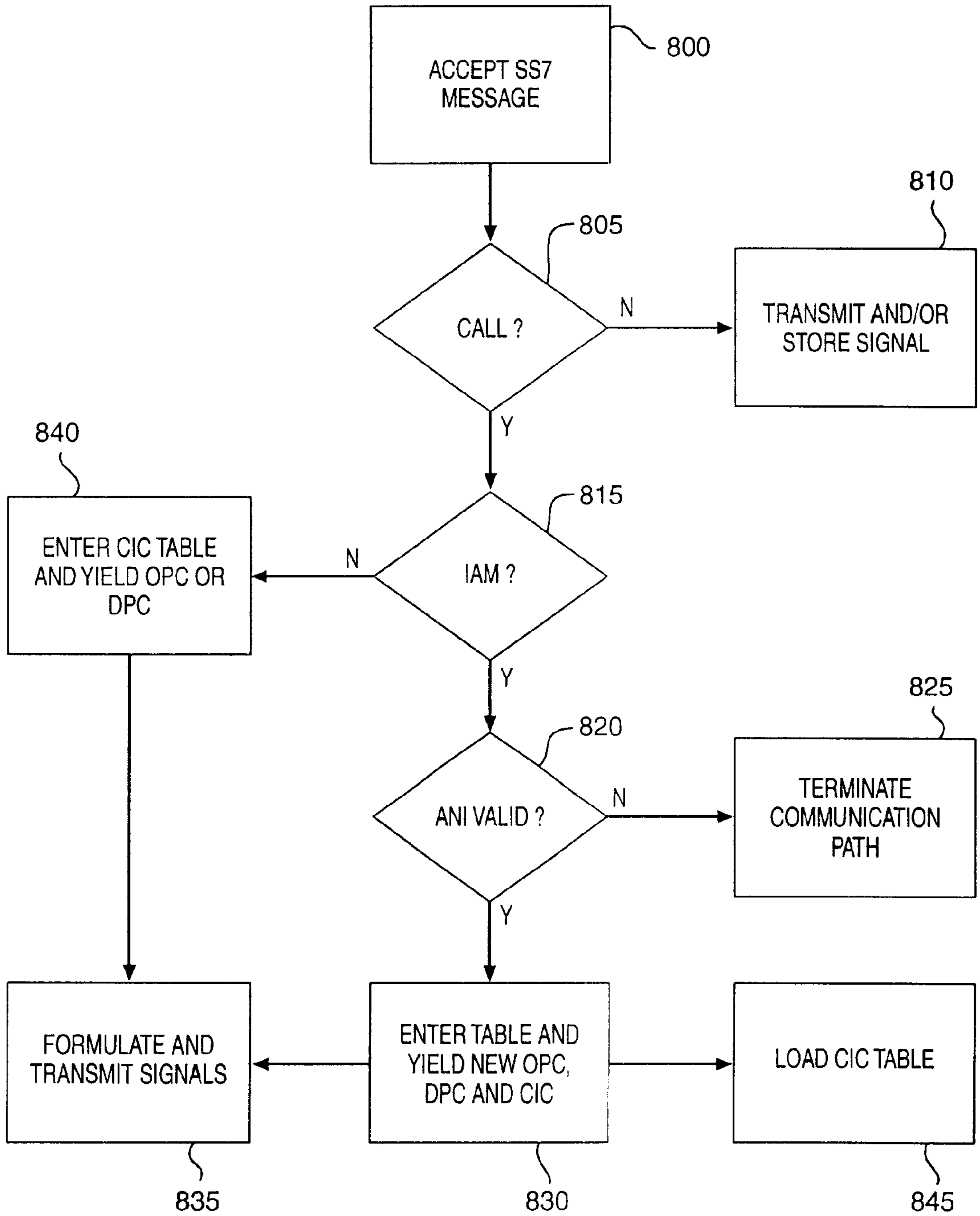

600
ACCEPT SS7 MESSAGES FROM LEC -- MTP (OPC, DPC) & ISUP (CIC)
605
ACCEPT SS7 MESSAGES FROM NB SWITCHES -- OM AND CPU OCCUPANCY
610
ACCEPT INFO FROM BB SWITCHES -- CONNECTIONS
615
PROCESS
620
SELECT NB SWITCH AND DS0 PORT
GENERATE BB SIGNALS -- NB SWITCH AND DS0 PORT FOR CONNECTION
625
630
FORMULATE SS7 MESSAGE -- OPC, DPC AND CIC
SIGNAL BB SWITCHES
635
640
SIGNAL NB SWITCH

FIG. 6



700
ACCEPT SS7 MESSAGES FROM NB SWITCH -- OPC, DPC, CIC
705
ACCEPT INFO FROM BB SWITCHES -- CONNECTIONS
710
PROCESS
715
SELECT DESTINATION
720
FORMULATE BB SIGNALS -- DESTINATION
730
ACCEPT BB SWITCH SIGNALS REGARDING CONNECTION
735
FORMULATE SS7 MESSAGE -- OPC, DPC AND CIC
725
SIGNAL BB SWITCHES
740
SIGNAL LEC

FIG. 7



ACCEPT SS7 MESSAGE
800
805
CALL ?
N
810
TRANSMIT AND/OR STORE SIGNAL
Y
840
ENTER CIC TABLE AND YIELD OPC OR DPC
N
815
IAM ?
Y
820
ANI VALID ?
N
825
TERMINATE COMMUNICATION PATH
Y
FORMULATE AND TRANSMIT SIGNALS
ENTER TABLE AND YIELD NEW OPC, DPC AND CIC
LOAD CIC TABLE
835
830
845

FIG. 8

METHOD, SYSTEM AND APPARATUS FOR TELECOMMUNICATIONS CONTROL

RELATED APPLICATIONS

This application is a continuation of Application Ser. No. 08/568,551 U.S. Pat. No. 5,825,780, filed on Dec. 7, 1995, which is a continuation of U.S. patent application Ser. No. 08/238,605, filed on May 5, 1994 and now abandonded. U.S. Pat. No. 5,825,780 and Application Ser. No. 08/238/605 are hereby incorporated by reference into this application.

FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not applicable

MICROFICHE APPENDIX

Not applicable

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to telecommunications and more specifically to communications control processing in telecommunications signaling.

2. Description of the Prior Art

Telecommunications systems establish a communications path between two or more points to allow the transfer of information between the points. The communications path typically comprises a series of connections between network elements. The network elements are typically switches. Switches provide the primary means where different connections are associated to form the communications path. Communication control is the process of setting up a communications path between the points. Communication control comprises the selection of network elements such as switches or other devices which will form part of the communications path. Communication control also comprises the selection of the connections between the network elements. Together, the network elements and connections which are selected make up the communications path. Typically, a plurality of different network element and connection selections may be possible for any one communications path between points.

Switches control these selections. Switches select the connections that comprise the communications path. Switches also select the network elements which form an actual part of that communications path. By selecting these network elements, a switch is often selecting the next switch that will make further selections. Switches accomplish communication control.

The correspondence between communication control and a communications path is well known in the art. A common method used in communication control is signaling among switches. One method by which a first point requests a communications path to a second point is by signaling a first switch with an off-hook signal followed by dual tone multifrequency (DTMF) signals. The first switch will typically process those signals and will select other network elements such as a second switch. The first switch signals the second switch and establishes a connection between the switches. The second switch then selects the next network element, signals that network element, and establishes a connection to that network element. This process is well known in the art. The connections and signaling thus proceed from switch to switch through the network until a communications path is established between the first and second points.

Some networks transmit signaling information from the switches to other signaling devices. In these cases, the switches typically must be modified through the use of Signaling Point (SP) hardware and software in order to convert the language of the switch into the language used by these other signaling devices. One signaling device is a Service Control Point (SCP). An SCP processes signaling queries from a switch. An SCP only answers a switch query after the switch has become a part of the communications path. SCPs support the communication control which is directed by the switch.

Additionally, signaling may pass through other signaling devices, such as Signal Transfer Points (STPs), which route the signaling. An STP is typically a high-speed packet data switch which reads portions of the signaling information and either discards or routes the information to a network element. The signal routing operation of the STP is based on the signaling information that is specified by the switch. STPs route signaling information, but STPs do not modify or otherwise process the signaling information. An example of the above described system is Signaling System #7 (SS7) technology. Thus, signaling devices only are used to support switches in communication control.

Broadband systems, such as Asynchronous Transfer Mode (ATM) may use extensions of existing SS7 signaling to allow ATM switches to direct communication control. However, broadband systems may also utilize different communication control methods. ATM switches may transfer ATM cells which contain signaling to other ATM switches. As with the other switch types however, ATM switches also perform the dual task of communication control and forming a part of the communications path.

Some switches use API switching which employs remote central processing units (CPUs). These switches only receive switch information from the remote CPUs and not signaling. The protocols used for information transfer between the switch and the remote CPU are proprietary among vendors and are incompatible between the switches of different vendors.

Some digital cross-connect (DCS) equipment employ centralized control systems. These systems, however, only provide relatively static switching fabrics and do not respond to signaling. Instead of establishing connections in response to signaling, DCS cross-connections are established in response to network configuration needs. Network elements and connections are pre-programmed into the network and are not selected in response to signaling from a point outside of the network.

At present, while communication control and the communications path are distinct from one another, both are dependent on the switch. The performance of both of these tasks by switches places limitations on a telecommunications network. One such limitation can be illustrated by one difficulty encountered in combining narrowband networks and broadband networks. Broadband networks are advantageous for data transmission because virtual permanent connections can be mapped through a network and bandwidth allocated on demand. Narrowband switches are advantageous for voice, in part, due to the many features which have been developed in conjunction with these switches. These features benefit both the user and the network through added efficiency and quality. Examples are "800" platforms, billing systems, and routing systems. However for broadband networks, the development of these features is incomplete and does not provide the functionality of current narrowband features. Unfortunately, narrowband switches do not have

the capacity, speed, and multimedia capabilities of broadband switches. The resulting combination is separate overlay networks. Typically, narrowband traffic remains within the narrowband network, and broadband traffic remains within the broadband network.

Any intelligent interface between the two networks would require that signaling information be transmitted between narrowband switches and broadband switches. At present, the ability of these switches to signal each other is limited. These switch limitations create a major obstacle in any attempt to interface the two networks. It would be advantageous if narrowband and broadband networks could interwork through an intelligent interface to establish a communications path between points. At present, the interface between narrowband and broadband networks remains a rigid access pipe between overlay systems.

The reliance on switches to both perform communication control and to form the a part of the communications path results in impediments to developing improved networks. Each time a new network element, such as a broadband switch, is introduced, a telecommunications network may be forced to delay integrating the network element into its network until standardization of signaling and interface protocols are developed for the switches. At present, there is a need for a portion of the communication control processing to be independent of the switches that form a part of the communications path.

SUMMARY

An embodiment of the present invention solves this need by providing a method, system, and apparatus for communication control processing that is located externally to the switches that make the connections. The method includes receiving a first signal into a processor which is located externally to the switches in a network comprised of network elements. The processor selects a network characteristic in response to the first signal. The processor then generates a second signal reflecting the network characteristic and transmits the second signal to at least one network element. This transmission occurs before that network element has applied the first signal. Examples of network characteristics are network elements and connections, but there are others. Examples of signaling are Signaling System #7 or broadband signaling. The processor may also employ information received from the network elements or operational control when making selections. In one embodiment, the method includes receiving the first signal into a network from a point and routing the first signal to the processor.

The present invention also includes a telecommunications processing system which comprises an interface that is external to the switches and is operational to receive and transmit signaling. The processing system also includes a translator that is coupled to the interface and is operational to identify particular information in the received signaling and to generate new signaling based on new information. The processor also includes a processor that is coupled to the translator and is operational to process the identified information from the translator in order to select at least one network characteristic. The processor provides new information to the translator reflecting the selection. The identified information is used in the processor before it is used in the particular network elements that receive the new signaling.

The present invention also includes a telecommunications network comprised of a plurality of network elements wherein at least one network element is a switch, and a plurality of connections between the network elements. The network also includes a processor located externally to the switches which is operable to receive a first signal, to select at least one network characteristic in response to the first signal, and to generate a second signal reflecting the selection. The network also includes a plurality of links between the processor and the network elements which are operable to transmit the second signal to at least one network element before that network element has applied the first signal.

The present invention also includes a telecommunications signaling system for use in conjunction with a plurality of telecommunication switches. This system comprises a plurality of signaling points and a signaling processor. The signaling processor is linked to the signaling points and resides externally to the switches. The signaling processor is operational to process signaling and to generate new signaling information based on the processing. The new signaling is transmitted over the links to multiple signaling points. In one embodiment, the new signaling information is comprised of different signaling messages and the different signaling messages are transmitted to different signaling points.

In another embodiment, a plurality of the signaling points each reside in a different switch and are directly coupled to a processor in the switch that directs a switching matrix in the switch in response to signaling processed by the signaling point. The signaling processor is operational to direct the switching matrixes of multiple switches by signaling multiple signaling points. The signaling processor is also operational to signal multiple points in response to signaling from a single source, and to signal a point in response to signaling from multiple sources.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features, aspects, and advantages of the present invention will become better understood with regard to the following description, claims, and drawings where:

FIG. **1** is a block diagram of a version of the invention.

FIG. **2** is a block diagram of a version of the invention.

FIG. **3** is a block diagram of a version of the invention.

FIG. **4** is a logic diagram of a version of the invention.

FIG. **5** is a flow diagram of a version of the invention.

FIG. **6** is a flow diagram of a version of the invention.

FIG. **7** is a flow diagram of a version of the invention.

FIG. **8** is a flow diagram of a version of the invention.

DESCRIPTION

Telecommunications systems establish communications paths between points which allow the points to transfer information, such as voice and data, over the communication paths. Typically, telecommunications systems are comprised of network elements and connections. A network element is a telecommunications device such as a switch, server, service control point, service data point, enhanced platform, intelligent peripheral, service node, adjunct processor, network element of a different network, enhanced system or other network related device, server, center or system.

A connection is the media between two network elements that allows the transfer of information. A few examples of connections are: digital T**1** lines, OC-**3** optical fibers, packet connections, dedicated access lines, microwave transmission, and cellular radio. As those skilled in the art are aware, connections can be described in a range from general to specific. All of the media between two switches

is a general description and might correspond to a virtual path in an ATM system or a trunk groups in a T1 system. An individual circuit between two elements is more specific and might correspond to a virtual channel in an ATM system or a DSO circuit in a T1 system. Connections can also be described as being logical or physical. Physical connections are electrical-mechanical media. Logical connections are paths which follow physical connections, but are differentiated from one another based on format and protocol. The term "connection" includes this entire range and the meaning varies according to the context in which the term is used. The present invention could make selections encompassing the entire range of connections.

A communications path is the combination of connections and network elements that physically transfers the information between points. A communication path may be point to point, point to multi-point, or multi-point to multi-point. These points, in turn, define the ends of the communications path. Thus, a connection may also be made between a network element and a point outside the network.

Signaling is the transfer of information among points and network elements and is used to establish communications paths. An example is Signaling System #7 (SS7). Signaling is typically transmitted over links, such as 56 kilobit lines. On the block diagrams, signaling is represented by dashed lines and connections are represented by solid lines.

In FIG. **1**, Telecommunications System **110** comprises a communication control processor (CCP) **120** and first, second, third, fourth, fifth and sixth network elements, **131**, **132**, **133**, **134**, **135** and **136** respectively. First and second network elements, **131** and **132** respectively, are connected by first connection **141**. First and third network elements, **131** and **133** are connected by both second and third connections, **142** and **143** respectively. First and fifth network elements, **131** and **135** respectively, are connected by fourth connection **144**. Second and fourth network elements, **132** and **134** are connected by fifth connection **145**. The third network element **133** is connected to fourth and sixth network elements, **134** and **136** by sixth and seventh connections, **146** and **147** respectively. Fourth and fifth network elements, **134** and **135** are connected by connection **148**. A first point **170**, which is located outside of the system **110**, is connected to first element **131** by first point connection **171**, and a second point **172** which is also located outside the system **110** is connected to fourth element **134** by second point connection **173**. First and second points, **170** and **172** respectively and first, second, third, fourth, fifth and sixth elements **131**, **132**, **133**, **134**, **135**, and **136** respectively each are linked to CCP **120** by first, second, third, fourth, fifth, sixth, seventh, and eighth links, **191**, **192**, **193**, **194**, **195**, **196**, **197** and **198** respectively.

As those skilled in the art are aware, a system is typically comprised of many more network elements, links, connections and points, but the number is restricted for clarity. Points outside of the network can take many forms, such as customer premises equipment (CPE), telephones, computers, or switches of a separate network system. In addition the system **110**, may take many forms such as international gateways, satellite networks, wireless networks, local exchange carriers (LECs), interexchange carriers (IXCs), transit networks, national networks, personal communicator systems (PCS), virtual private networks, or connection oriented networks such as local area networks (LANs), metropolitan area networks (MANs), wide area networks (WANs) to name some examples.

In operation Telecommunications System **110** is able to accept information from first point **170** and second point **172** and transmit the information over the various network elements and connections which form the communications path. System **110** is also capable of exchanging signaling with first point **170** and second point **172** over the first link **191** and second link **192**.

On a standard call that establishes a communications path from first point **170** to second point **172**, first point **170** will signal Telecommunications System **110** that it requests the communications path. This signaling is directed to CCP **120** over first link **191**. CCP **120** processes the signaling and selects at least one network characteristic in response to the signaling. Network characteristics might be network elements, connections, network codes, applications, or control instructions to name a few examples. The selected network characteristic typically comprises one of a plurality of network elements and/or connections. The CCP **120** generates signaling which is preferably new signaling reflecting the selection. CCP **120** then transmits the signal to at least one of a plurality of network elements before that network element has applied the signal.

In one embodiment, CCP **120** selects the network elements and the connections that comprise the communications path. However, first point **170** will typically seize first point connection **171** contemporaneously with signaling. This initial connection could also be selected by CCP **120** from the available possibilities after the signaling by first point **170**. Assuming first point **170** has seized first point connection **171** to first element **131**, CCP **120** selects one, a plurality, or all of the remaining network elements and connections to further establish a communications path to second point **172**.

CCP **120** determines which element should be connected to first element **131**. CCP **120** could select either second element **132** or third element **133**. If third element **133** is selected, CCP **120** may also select the connection to third element **133** from among second and third connections, **142** and **143** respectively. If third connection **143** is selected, CCP **120** will signal first element **131** over third link **193** to further the communications path to third element **133** over third connection **143**.

CCP **120** may then make further selections to complete the communications path. As the possibilities have been limited for clarity, CCP **120** would make the selections and signal the elements as follows. CCP **120** would signal third element **133** over fifth link **195** to further the communications path to fourth element **134** over sixth connection **146**. CCP **120** would signal fourth element **134** over sixth link **196** to further the communications path to second point **172** over second point connection **173**. CCP **120** would also signal second point **172** over second link **192** of the communications path available through second point connection **173**. In this way, the communications path requested by first point **170** is selected by CCP **120** and signaled to the elements. Throughout this process, CCP **120** may receive status messages and signaling from the elements to support its processing. This status messaging may be transmitted and received over links, connections, or other communication means.

In another embodiment, CCP **120** may select only the network elements and not the connections. The elements would select the connections to use based on the network element selected by CCP **120**. For this embodiment, the main difference from the above example is that CCP **120** would instruct first element **131** to further the communications path to third element **133**, but first element **131** would select the actual connection used from among second and

third connections, **142** and **143**, respectively. First element **131** may signal CCP **120** over third link **193** of its selection so that CCP **120** may signal third element **133** of the connection over fifth link **195**. In this embodiment, CCP **120** would specify the network elements to the elements, which in turn, would select the connections between those network elements.

There are situations in which the selection of a network element and the selection of a connection signify the same thing. On FIG. **1** for example, instructing first element **131** to use first connection **141** is synonymous with an instruction to connect to second element **132**. This is because the connection inevitably connects to the element. The selection of a connection may effectively select a network element, and the selection of a network element may effectively select a connection (or a group of specific connections) to that network element.

One skilled in the art will recognize that the selection process can be distributed among the CCP and the elements. The CCP might select all the network elements, a portion of the network elements, or none of the network elements leaving the switches to select the remainder. The CCP might select all of the connections, a portion of the connections, or none of the connections, again leaving the elements to select the remainder. The CCP may select combinations of the above options, but the CCP will always select at least one network characteristic.

In another embodiment, first point **170** may want to access a other network elements such as servers, platforms or operator centers. For example, such elements could be located at either fifth or sixth network elements **135**, and **136** respectively. CCP **120** will receive signaling from first point **170** over first link **191** indicating this request, and first point **170** will typically seize first point connection **171** to first element **131**. Again CCP **120** will select network elements. If sixth element **136** is selected, CCP **120** could select a communications path from first element **131** through either second element **132** to fourth element **134** and then to third element **133**, or through a direct connection from first element **131** to third element **133**. If CCP **120** selects the latter, it would signal first element **131** to further the communications path to third element **133**, and it would signal third element **133** to further the communications path to sixth element **136**. As discussed in the above embodiments, CCP **120** may also select the connections, or the elements may be left with that task.

As is known in the art, in-band signaling is typically used in many user to network connections, such as the local loop. This is because only one connection or link is typically provided to the user premises and thus, the signaling must be placed on the actual communications path. The initial network switch typically removes the signaling from the communications path and transfers it to an out-of-band signaling system. The current invention is fully operational in this context. Although the switch may receive the signaling initially, it will only route the signaling to the CCP for processing. Even if in-band signaling is used within the network, the switches could remove signaling from the communications path and route it to the CCP for processing in accord with the present invention.

Thus, preferably the CCP processes signaling before it is applied or processed by the switch such as to select connections or generate queries. Preferably, no or minimal changes are made to the signaling prior to the signaling being received by the CCP so that the CCP receives the signaling in the same format as a switch would receive the signaling. The CCP may also process the signaling in that format. The switches make their selections based on the CCP selections, thus the switch selections clearly occur after the CCP has processed the signaling. As such, the switch may route signaling to the CCP, but the switch does not apply the signaling. Some examples of a switch applying the signaling would be selecting network elements or generating queries for remote devices.

In one of the above embodiments, the switches did not select the network elements and connections, initiate the signaling, or otherwise control the communication. The switches only followed the instructions of the CCP and actually made the connections that furthered the communications path. In one embodiment, the switches were allowed to select the actual connections used, but even these selections were based on CCP selections.

As illustrated above, the CCP allows a telecommunications network to separate communication control from the communications path. In prior systems, the switches would select the network elements and the connections, as well as, actually providing a part of the actual connection. As a result, prior systems are restricted to the communication control capabilities provided by the switches. Prior systems have used remote devices, such as an SCP, to support switch control, but the remote device only answered queries in response to the switches processing of the signal. These remote devices do not process the signaling before the switch had already applied the signaling. By using the CCP, telecommunications systems can control communications independently of the capability of the switches to accomplish both tasks.

FIG. **2** shows a block diagram of another embodiment of the present invention. CCP **250** and network **210** are shown. CCP **250** is a communications control processor. CCP **250** could be integrated into network **210**, but need not be and is shown separately for clarity. Network **210** could be any type of telecommunications network that operates using network elements, signaling, and connections. Examples would be LECs, IXCs, LANs, MANs, WANs, and Cellular Networks, but there are others. Additionally, network **210** could be narrowband, broadband, packet-based, or a hybrid. Network **210** is capable of providing communications paths between points both inside and outside of network **210**. CCP **250** and network **210** are linked by link **214** and are able to signal each other in order to establish these paths.

Additionally, user **220** and user **230** are shown and are also capable of signaling. Examples of users **220** and **230** might be telephones, computers, or even switches in another telecommunications network. Users **220** and **230** are connected to network **210** by connections **222** and **232** respectively. Users **220** and **230** are linked to CCP **250** by links **224** and **234** respectively. Signaling may be transmitted over links **224** and **234**. If in-band signaling is employed on connections **222** and **232**, network **210** would separate at least a portion of the signaling out-of-band and transmit it to CCP **250** over link **214**.

Also shown are various network elements. As with CCP **250**, these elements could also be integrated into network **210**, but are shown separately for clarity. These network elements are: networks **260**, operator centers **262**, enhanced platforms **264**, video servers **266**, voice servers **268**, and adjunct processors **270**. This is not an exclusive list. Those skilled in the art will recognize these network elements and their functions, as well as the many other types of telecommunications devices, such as billing servers, that are applicable in this situation.

Each network element is connected to network **210** by connection **212**. Connection **212** represents several actual connections between the network elements (**260–270**) and different elements in network **210**. One bus-type connection is shown for purposes of clarity, but those skilled in the art are familiar with many actual types of connections to use. Additionally link **256** is shown from CCP **250** to the network elements (**260–270**). Link **256** is similarly represented as a bus-type link for clarity, and multiple links are actually used, although some network elements may not even require links. Link **214** has been simplified for clarity in the same fashion.

In one embodiment, user **220** may desire to establish a communications path to user **230**. CCP **250** would make the appropriate selections and signal the network elements in network **210** as discussed with regard to the embodiments of FIG. **1**. As a result, a communications path would be established from user **220** to user **230** through network **210** and connections **222** and **232**.

In another embodiment, user **220** may desire to access one of the various network elements (**260–270**). User **220** will typically seize connection **222** to network **210** and generate signaling. Both in-band signaling on connection **222** and out-of-band signaling on link **224** would be directed to CCP **250**. By processing the signaling, CCP **250** can select any of the network elements (**260–270**) and control the communications through network **210** and connection **212** to the network elements (**260–270**).

For example, should user **220** desire to connect to a video server and another network, user **220** would signal the request. The signaling would be directed to CCP **250** over link **224**, or over connection **222** and link **214** as discussed above. CCP **250** would process the signaling and make the appropriate selections. CCP **250** would signal network **210** and video servers **266** of its selections. As a result, a communications path would be set-up from user **220** to video servers **266**.

Additionally, CCP **250** would control communications to the other network which is represented by networks **260**. Networks **260** could be any other form of telecommunications network—either public or private. CCP **250** would make the appropriate selections to further the communications path over connection **212** and network **210** to networks **260**. Upon signaling from CCP **250**, the connections comprising the communications path would be made. Networks **260** would also be signalled by CCP **250** over link **256**. As such a communication path is set up from user **230** to video servers **266** and on to networks **260**.

There may also be several devices represented by particular network element shown on FIG. **2**. CCP **250** could also select the particular device to access. For example, take the situation in which voice servers **268** represents **20** individual voice server devices split among three different locations. On each call, CCP **250** could select the actual voice server device which should be used on that call and control the communications through network **210** and connection **212** to the selected device. Alternatively, CCP **250** may only be required to select group of devices, for instance at a particular location, instead of the actual device.

As is known, large telecommunication networks are comprised of numerous network elements, connections, and links. The present invention is suitable for use in this context. FIG. **3** shows a version of the present invention in the context of a large network. Typically, this network would be comprised of several broadband switches, narrowband switches, muxes, signal transfer points (STPs), Service Control Points (SCPs), operator centers, video servers, voice servers, adjunct processors, enhanced services platforms, connections, and links. For purposes of clarity, only a few of these possibilities are shown on FIG. **3**. For the same reason, connections and links are not numbered.

FIG. **3** shows Telecommunications Network **310** which is comprised of STP **340**, STP **345**, CCP **350**, SCP **355**, broadband switches **360**, **362**, **364**, and **366**, interworking units **361** and **365**, narrowband switches **370** and **375**, and muxes **380**, **382**, **384**, and **386**. Aside from CCP **350**, these elements of a large network are familiar to one skilled in the art and examples of the of these network elements are as follows: STP—DSC Communications Megahub; SCP—Tandem CLX; broadband switch—Fore Systems ASX-**100**; narrowband switch—Northern Telecom DMS-**250**; and mux—Digital Link Premis Way with CBR module.

In at least one embodiment, the broadband switches are equipped with signaling interworking units. These units translate SS7 messages into B-ISDN messages. In that event, the CCP could transmit SS7 to the broadband switches which could convert the signals properly. Interworking is discussed in ITU-TS Recommendation Q.2660, "B-ISDN, B-ISUP to N-ISUP Interworking".

When user information passes from a broadband network to a narrowband network, it typically must pass through a mux. Muxes can convert transmitted information back and forth between narrowband and broadband formats. In at least one embodiment, each broadband connection on one side of a mux corresponds to a narrowband connection on the other side of the mux. In this way, the CCP can track connections through the mux. If the communication path is on a given narrowband connection entering the mux, it will exit the mux on its corresponding broadband connection. This correspondence allows the CCP to identify connections on each side of the mux based on the entry connection. Muxes are typically placed at any interface between narrowband and broadband connections.

As long as the connections correspond through the mux, the CCP can track the communication path properly. Alternatively, the connections may not correspond. In that case, signaling links between the muxes and the CCP would be required for the devices to communicate and allow the CCP to track the communication path.

Additionally, Telecommunications Network **310** includes the connections and links which are not numbered. These connections and links are familiar to those skilled in the art. Some examples of possible connections are switched digital lines, satellite links, microwave links, cellular links, and dedicated digital lines, but there are others. The signaling links are typically data links, such as 56 kilobit lines. The signaling may employ SS7, Broadband, C**6**, C**7**, CCIS, Q.933, Q.931, T1.607, Q.2931, B-ISUP or other forms of signaling technology. The present invention is fully operational with the many variations which are well known in the art. Additionally, it is also known that a direct link between two devices can be used instead of an STP for signal routing.

Outside of Telecommunications Network **310** are first point **320**, second point **330**, LEC switch **325**, LEC switch **335**, LEC STP **328**, and LEC STP **338**. These devices are shown along with their links and connections. First point **320** is connected to LEC switch **325**. LEC switch **325** is linked to LEC STP **328** which routes signaling from LEC switch **325**. LEC switch **325** is also connected to mux **380** of Telecommunications Network **310**. LEC STP **228** is linked to STP **340** of Telecommunications Network **310**.

STP **340** is linked to STP **345**. The other links are as follows. STPs **340** and **345** are linked to CCP **350**. CCP **350**

is linked to interworking units **361** and **365** of broadband switches **360** and **364** respectively. CCP **350** is linked to broadband switches **362** and **366**, and narrowband switch **375**. STP **345** is linked to narrowband switch **370** and SCP **355**. STP **345** is also linked to LEC STP **338** which is linked to LEC switch **335**.

Mux **380** is connected to broadband switch **360**. Broadband switch **360** is connected to broadband switches **362** and **364**. Broadband switch **362** is connected to mux **384** which is connected to narrowband switch **375**. Broadband switch **364** is connected to mux **382** which is connected to narrowband switch **370**. Broadband switches **362** and **364** are both connected to broadband switch **366**. Broadband switch **366** is connected to mux **386** which is connected to LEC switch **335**. LEC switch **335** is connected to second point **330**.

When a call is placed from first point **320** that requires the use of Telecommunications Network **310**, LEC switch **325** will typically seize a connection to Telecommunications Network **310** and generate a signal containing call information. At present, this signal is in SS7 format and the seized connection is a DS**0** port. The signal is transmitted to LEC STP **328** which transfers it on to STP **340**. LEC switch **325** also extends the communication path over the seized connection. These LEC components and the process of establishing communication paths between a point, a LEC, and an IXC are familiar to those skilled in the art.

Telecommunications Network **310** accepts the communication path on the narrowband side of mux **380**. The present invention can also accept broadband calls that do not require a mux, but typically, calls from a LEC will be narrowband. Mux **380** converts the call to broadband and places it on the broadband connection that corresponds to the seized connection. The communication path extends to broadband switch **360** through mux **380**.

STP **340** transfers the signal from LEC STP **328** to STP **345** which, in turn, routes the signal to CCP **350**. Also, CCP **350** accepts status messages from the broadband and narrowband switches over standard communications lines, and may query SCP **355** for information. Any suitable database or processor could be used to support CCP **350** queries. CCP **350** uses this information and its own programmed instructions to make communication control selections. For calls that require narrowband switch treatment, CCP **350** will select the narrowband switch.

Preferably, CCP **350** can select any narrowband switch in Telecommunications Network **310**. For example, it may extend the communication path through the broadband network to a narrowband switch across the network for processing, or it may extend the communication path to a narrowband switch connected to the broadband switch that originally accepts the communication path. Additionally, no narrowband switch may be required at all. For clarity, all of the switches representing these possibilities are not shown on FIG. **3**.

CCP **350** will select at least one network characteristic in response to the signaling. Typically, this will be the network elements or connections that will make the communication path. As discussed with regard to the above embodiments, CCP **350** may select only the network elements and allow the switches to select the connections, or the selections can be distributed among the two. For example, CCP **350** may only select some of the network elements and connections and allow the switches to select some of the network elements and connections. CCP **350** might only select the narrowband switches and allow the broadband switches to select the broadband switches that will make the communication path. CCP **350** can also select other network characteristics, such as applications and control instructions.

In one embodiment, CCP **350** will select the narrowband switches to process particular calls and the DS**0** ports on those switches which will accept these calls. The broadband switches will select the broadband switches and the broadband connections to the DS**0** port. Restricted to the possibilities depicted on FIG. **3**, CCP **350** may select either narrowband switch **370** or narrowband switch **375** to process the call. Assuming CCP **350** selects narrowband switch **370**, it would also select a DS**0** port on narrowband switch **370** to accept the connection. CCP **350** would then signal broadband switch **360** through interworking unit **361** to further the communications path to the selected DS**0** port on narrowband switch **370**.

Of the possible routes, broadband switch **360** would be left to select the other broadband switches and connections to use. Assuming the route directly to broadband switch **364** is selected, broadband switch **360** would further the communications path to that switch. Broadband switch **360** would also signal broadband switch **364** of the communication path. Broadband switch **364** would further the communication path to through mux **382** to access the specified DS**0** port on narrowband switch **370**. This is accomplished by corresponding the connections through the mux as discussed above. CCP **350** will signal narrowband switch **370** of the incoming communication path. This signal is routed by STP **345**. Narrowband switch **370** will process the call on the specified DS**0** port. Typically, this would include billing and routing the call. Narrowband switch **370** may also query SCP **355** to aid in application of services to the call. For example, narrowband switch **370** may retrieve an "800" translation from SCP **355**. As a result of the processing, narrowband switch **370** will switch the call and generate a new signal which may include routing information. The signal is sent to CCP **350** through STP **345**. The communication path is furthered on a new connection back to broadband switch **364** through mux **382**. CCP **350** may use the information in the signal, SCP information, network element information, operational instructions, and/or its own routing logic to make new selections for the call. The network element information and operational instructions could be signalled to CCP **350** or delivered over standard data lines.

In one embodiment, the selection of a network characteristic will include the selection of a network code. Network codes are the logical addresses of network elements. One such code is a destination code that facilitates egress from Telecommunications System **310**. The destination code typically represents a network element that is connected to a LEC switch. Once a destination is selected, CCP **350** will signal broadband switch **364** of its selections and the communication path will be furthered through the broadband network accordingly. In the current example this could be through broadband switch **366** and mux **386**. The communication path would be furthered to the specified port on LEC switch **335**. Typically, this involves the seizure of a connection on the LEC switch by the IXC.

In one embodiment, whenever broadband switch **366** extends a communication path to mux **386**, it is programmed to signal CCP **350** of the broadband connection it has selected. This allows CCP **350** to track the specific DS**0** port on the LEC switch that has been seized. CCP **350** would signal LEC switch **335** through STP **345** and LEC STP **338** of the incoming call on the seized DS**0** connection. As a result, LEC switch **335** would further the communication path to second point **330**.

It can be seen from the above disclosure that the present invention allows a telecommunications network to employ a broadband network to make call connections. By using muxes to convert calls and a CCP to analyze signaling, this broadband network remains transparent to the networks of other companies. An example of such a transparent interface is between an interexchange carrier (IXC) network and a local exchange carrier (LEC) network. Similarly the network will be transparent if deployed in only a portion of a single company's network infrastructure. In the above embodiment, the LEC seizes an IXC DS**0** port and signals to an IXC STP. The mux and the CCP convert the call and analyze the signal appropriately. No changes in other existing carrier systems, such as LEC systems, are required.

Additionally the narrowband switch receives the call and signal in its own format and switches the call. Although the switch may "think" the call is routed over a trunk to another narrowband switch, the call actually goes right back to the mux and broadband switch that sent the call. The narrowband switch is used to apply features to the call, i.e. billing, routing, etc. The broadband network is used to make the substantial portion of the call connection. The CCP may use narrowband switch call processing information to make selections.

The CCP performs many functions. In one embodiment, it accepts signaling from a first point or LEC and provides appropriate signals in accord with the communication control selections it has made. These selections are network characteristics. The CCP may select network elements such as switches, servers, or network codes. The CCP may select connections, such as DS**0** circuits and ports. The CCP may select particular telecommunications applications to be applied to the communications path. The CCP may select particular control instructions for particular devices. The CCP may also receive information from entities such as SCPs, operational control, or switches to aid in its selections.

The CCP is a processing system, and as such, those skilled in the art are aware that such systems can be housed in a single device or distributed among several devices. Additionally, multiple devices with overlapping capabilities might be desired for purposes of redundancy. The present invention encompasses these variations. One such operational system would be multiple pairs of CCPs located regionally within a telecommunications system. Each machine would be equally capable of communication control. One example of a CCP device would be a Tandem CLX machine configured in accord with this disclosure of the present invention.

A signaling point handles the signaling for a switch. Switches which are used to route calls typically have a signaling point which is directly coupled to a processor in the switch. This processor controls a switching matrix in the switch in response to the signaling processed by the signaling point. Thus, there is typically a one to one correspondence of a signaling point for each switch and matrix.

The CCP is not directly coupled to one switch, one switch processor (CPU), or one switching matrix. In contrast, the CCP has the capability of directing a plurality of switches. Thus, the CCP can direct multiple switch matrixes by signaling multiple signaling points.

It is possible to house the CCP within other telecommunication devices, even switches. Although the CCP can be primarily distinguished from a switch CPU based on physical location, this does not have to be the case. A switch CPU receives information from a signaling point and controls the matrix of a single switch. Some switches distribute the matrix among different physical locations, but the CPU controls each matrix based on information received from a single signaling point. This information is not signaling.

In contrast, the CCP receives signaling and has the ability to signal other network elements. It can communicate with multiple signaling points. These signaling points provide information to the switch CPUs which control the switch matrixes. By signaling multiple signaling points, the CCP is able to direct the matrixes of multiple switches based on the signaling and other information the CCP obtains. A CCP is not associated with a single switch matrix. A CCP does not require communication path connections in order to operate.

The main capabilities of one version of a CCP are shown on FIG. **4**. CCP **450** comprises interface **460**, translator **470** operably connected to interface **460**, processor **480** operably connected to translator **470**, and memory **490** operably connected to processor **480**.

CCP **450** functions to physically connect incoming links from other devices such as STPs, switches, SCPs, and operational control systems. Interface **460** is functional to accept the signals off of these links and transfer the signals to translator **470**. Interface **460** is also be able to transfer signaling from translator **470** to the links for transmission.

Translator **470** accepts the signaling from interface **460** and identifies the information in the signaling. Often, this will be done by identifying a known field within a given signaling message. For example, translator **470** might identify the Origination Point Code (OPC), Destination Point Code (DPC), and Circuit Identification Code (CIC) in an SS7 message. Additionally, translator **470** must be able to formulate outgoing signaling and transmit it to interface **460** for transmission. For example, translator **470** might replace the OPC, DPC, and CIC in a given SS7 message and transfer the modified SS7 message to interface **460** for transmission. Translator **510** must be equipped to manage the signaling formats it will encounter. Examples are SS7 and C**7**.

Processor **480** accepts the signaling information from translator **470** and makes the selections that accomplish communication control. This includes the selection of the network elements and/or connections that make the communications path. Typically, selections are made through table look-ups and SCP queries. Tables are entered and queries are generated based in part on the information identified by translator **470**. The table look-ups and SCP information retrieval yield new signaling information. The new information is transferred to translator **470** for formulation into appropriate signals for transmission. Algorithm solution could also be used to make selections. Processor **480** also handles various status messages and alarms from the switches and other network elements. Operational control can also be accepted. This information can be used to modify the look-up tables or selection algorithms. Memory **490** is used by processor **480** to store programming, information, and tables.

FIG. **5** shows a flow diagram for the CCP for a version of the present invention. The sequence begins with the CCP receiving different types of information. Box **500** depicts the CCP accepting a signal from a first point. This signal could be in any format, such as SS7 or broadband signaling. The signal may have passed through STPs from a LEC over a signaling link, or it may also be a signal directly provided by an individual user of a network. The signal contains information about the requested communication path. An example of such information is the message type which indicates the purpose of the message. Another example of such information is set-up information such as transit net-

work service value, bearer capability, nature of address, calling party category, address presentation restriction status, carrier selection value, charge number, and originating line information, and service code value. Other information might be a network indicator or a service indicator. Those skilled in the art are familiar with these types of information.

Other types of information might also be accessed by the CCP. The network elements, such as switches, may provide the CCP with information as shown in box **505**. This information allows the CCP to select network elements and connections based on network conditions. Examples of possible types of such information could be management messages, loading, error conditions, alarms, or idle circuits. The CCP might also provide the network elements with information.

Box **510** shows that operational control might be provided. Operational control allows system personnel to program the CCP. An example of such control might be to implement a management decision to retire a particular network element. Operational control would allow the removal that element from the selection process.

The CCP processes the information is has received in box **515**. Processing also entails the use of programmed instructions in the CCP, and might even include the use of information retrieved from a remote database, such as an SCP. The selections are then made as shown in box **520**. These selections specify network characteristics, such as network elements and/or connections. As stated above, The CCP may only select a portion of the network characteristics and allow the points or the switches to select the remainder. It should be pointed out that the information used in processing is not limited to that which is listed, and those skilled in the art will recognize other useful information which may be sent to the CCP.

Once network characteristics are selected, the CCP will signal the points and the applicable network elements of the selections. In box **525**, signals are formulated instructing the network elements of the network characteristics selected. The signals are transmitted to the appropriate network elements in box **535** which will typically result in a communication path through the network elements and connections. Other activity, such as applications and control procedures might be implemented as well. Additionally, in boxes **530** and **540**, signals are formulated and sent to the points. Typically the new signals generated by the CCP are sent to network elements or multiple signaling points. These new signals could be the same, however different signaling is typically sent to the different network elements which may used as part of a communication path.

FIG. **5** represents the sequence that the CCP performs in one embodiment to control communications and establish a communication path from a first point to a second point through network elements and connections. FIGS. **6** and **7** represent a similar sequence, and they are in the context of an Interexchange Carrier (IXC) similar to that depicted in FIG. **3**. The IXC accepts DS**0** connections and SS7 signaling from a LEC and employs a broadband system to make the substantial portion of the communication path.

FIG. **6** depicts the flow of the CCP in a version of the present invention when a communication path is established from the LEC to a narrowband switch in the IXC. Box **600** shows that an SS7 message is accepted from the LEC which contains a Message Transfer Part (MTP) and an Integrated Service User Part (ISUP). As those skilled in the art are aware, the MTP contains the Originating Point Code (OPC) and the Destination Point Code (DPC). These point codes define specific signaling points in the network and are typically associated with a switch. As such, the OPC and DPC define a portion of the desired communication path.

When the communication path is extended into the IXC network, the OPC designates the LEC switch that connected to the IXC (#325 on FIG. **3**). Previously, the DPC has designated the narrowband switch that the LEC would connect to for calls into the IXC. In this embodiment of the present invention, the DPC may designate a particular narrowband switch from the LEC's perspective, but the CCP actually selects the actual narrowband switch used. A mux or a broadband switch accepts the connection from the LEC, not a narrowband switch.

The ISUP contains the Circuit Identification Code (CIC) which designates the DS**0** port that the LEC has seized. Previously, this DS**0** Port was on a narrowband switch, but in this embodiment of the present invention, the DS**0** port is actually on a mux.

Box **605** shows that the CCP may receive status information from the narrowband switches. These messages include Operational Measurements (OM) and CPU Occupancy information. OM includes trunk usage status of the switches which tells the CCP which DS**0** ports are available on the narrowband switches. CPU Occupancy tells the CCP of the specific switching load of each narrowband switch. Box **610** shows that the CCP may also accept status information from the broadband switches indicating which connections are idle. This information allows the CCP to specify and balance routing through the broadband switches if desired. As discussed in relation to some of the other embodiments, the broadband switches may be left with that selection.

The CCP processes the information it has received in box **615**. Those skilled in the art are aware of other information which would be useful in this context. As a result of the processing, a narrowband switch and a DS**0** port on that switch are typically selected as shown in box **620**. The selected narrowband switch may be close to the LEC or across the broadband network. The CCP determines which narrowband switch will process the call. This makes the narrowband switches virtually interchangeable.

Box **625** shows that a signal indicating these selections is generated and sent to the appropriate broadband switches in box **635**. As discussed, the broadband switches may employ interworking units to handle signaling. Typically, the broadband switches will use internal tables to select broadband connections based on information in the signal from the CCP. Such information might identify the existing extent of the communication path and specify the narrowband switch and the DS**0** port on that switch to which the communication path should be extended. The tables would be entered with this information and yield a particular broadband connection to use. Broadband switches further along the communications path could also receive similar signals from the CCP and use similar tables. Alternatively, the broadband switches further along the communications path might only need to enter an internal table using the incoming broadband connection and yield a new broadband connection on which to extend the communications path.

Those skilled in the art are familiar with broadband systems which can accomplish this. Broadband signaling is discussed in the following ITU-TS Recommendations: Q.2762 "B-ISDN, B-ISDN User Part—General Functions of Messages"; Q.2763 "B-ISDN, B-ISDN User Part—Formats and Codes"; Q.2764 "B-ISDN, B-ISDN User Part—Basic

Call Procedures"; Q.2730 "B-ISDN, B-ISDN User Part—Supplementary Services"; Q.2750 "B-ISDN, B-ISDN User Part to DSS2 Interworking Procedures"; and Q.2610 "Usage of Cause and Location in B-ISDN User Part and DSS2".

In at least one embodiment, the broadband switches are equipped with signaling interworking units. These units translate SS7 messages into B-ISDN messages. In that event, the CCP could transmit SS7 to the broadband switches which could convert the signals properly.

Interworking is discussed in ITU-TS Recommendation Q.2660 "B-ISDN, B-ISUP to N-ISUP Interworking".

In one embodiment, the broadband switches may select the actual virtual connection that corresponds through a mux to a DS**0** port. This DS**0** port could be on a narrowband switch or a on a point, such as a LEC switch. In this case, the CCP would not need to select a DS**0** port since the broadband switch was in effect doing so. The internal tables of the broadband switches would be programmed to trigger when the particular broadband switch was connecting to particular broadband connections. These connections might be to a DS**0** port on a narrowband switch or any specified point. Upon the trigger, the broadband switch would signal the CCP of the broadband connection it has used. The CCP would incorporate this information into the signal it sends to the narrowband switch or specified point. It is preferred that the CCP select the DS**0** port on the selected narrowband switches, and that the broadband switches be allowed to select the broadband connection out of the network (through a mux) and signal the CCP of its selection.

The SS7 message from the LEC informed the CCP which DS**0** port had been seized (the CIC), on which IXC device (DPC), and by which LEC switch (the OPC). By tracking the DS**0** Port through the mux (#380 on FIG. **3**), the CCP knows which connection the communication path will use to get to the broadband switch (#360 on FIG. **3**). The CCP provides the broadband network with the proper signaling to extend the communication path from this switch to the selected narrowband switch as shown in box **635**.

Box **630** shows that the CCP formulates an SS7 message based on the selections relating to the narrowband switch. SS7 message formulation methods, such as drop and insert, are known in the art. A new DPC is inserted that will designate the narrowband switch selected by the CCP. A new CIC is inserted that will designate the DS**0** port on that switch as selected by the CCP. The SS7 message is sent to the narrowband switch in box **640**.

As such, the communication path is extended from the LEC through the broadband network to the narrowband switch, and the narrowband switch is notified of the incoming communication path. Another portion of the SS7 message contains call information including ANI and DNIS. This information was supplied by the LEC and is in the SS7 message sent to the narrowband switch.

The narrowband switch uses this information along with its own programming to switch the call. This switching may include various switching programs and remote databases. The narrowband switch will select a new DPC based on this processing. It will switch the call to a new DS**0** port. Previously, this port was connected to a trunk connected to the next narrowband switch in the call routing scenario. However, in the present invention, the DS**0** port is connected through a mux to broadband switch. The narrowband switch will place the new DPC in an SS7 message. Along with the new DPC, a new CIC identifying the new DS**0** circuit, and a new OPC designating the narrowband switch itself is placed in the SS7 message and sent to the CCP.

FIG. **7** shows the flow of the CCP when extending a communication path from the selected narrowband switch to a point outside of the IXC in one embodiment of the present invention. The SS7 message generated by the narrowband switch after processing the call is received by the CCP in box **700**. In it, the CIC designates the DS**0** port the communications path extends from on the narrowband switch. Because this port is connected to a mux with corresponding connections, the CCP can determine which connection the communication path uses to extend back to the broadband switch.

The CCP may also receive status information from the broadband switches as shown in box **705**. This information allows the CCP to select broadband connections if desired. As discussed, the broadband switches may make these selections. Typically, the broadband switches will use internal tables to select broadband connections based on information in the signal from the CCP. Such information might specify destination code. The destination code might correspond to a terminating switch or a LEC switch to which the communication path should be extended.

As shown in box **710**, the CCP applies processing and selects the appropriate destination for the broadband network to extend the communication path to as shown in box **715**. The CCP may use the new DPC provided by the narrowband switch to identify the destination for the broadband communication path.

In box **720**, signals are generated reflecting this selection and sent to the appropriate broadband switches in box **725**. As discussed, the broadband switch may trigger and signal the CCP when it uses particular connections. This would occur for a connection through a mux to a LEC switch. This signal is accepted by the CCP in box **730** and is used to identify the DS**0** port. An SS7 message is formulated in box **735** and in it the CIC will identify this DS**0** connection on the LEC switch (#335 on FIG. **3**). Alternatively, this DS**0** port may have been selected by the CCP and signalled to the broadband switch. The LEC is signalled in box **740**.

From FIGS. **6** and **7**, a sequence is shown that demonstrates the procedures that the CCP can follow to accept signaling from the LEC and make selections that control communications through the IXC network. The CCP must produce signals to implement its selections and transmit them to the applicable network elements. The CCP is able to use the routing, billing, and service features of a narrowband switch, but is still is able to employ a broadband network to make a substantial part of the communications path.

FIG. **8** is a flow diagram of CCP signal processing in one embodiment of the invention.

Box **800** shows that an SS7 signal has been accepted by the CCP. Box **805** shows that the CCP determines the message type. If the message is not a call message, it is routed or used to update the CCP memory if appropriate as shown in box **810**. Non-call messages are familiar to those skilled in the art with examples being filler or management messages. If the SS7 message is a call message, it is examined to determine if it is an initial address message (IAM) in box **815**. Call messages and IAMs are familiar to those skilled in the art. If it is an IAM, the information provided by automatic number identification (ANI) is used to validate the call in box **820**. ANI validation is accomplished with a table look-up and is well known. If invalid, the communication path is terminated as shown in box **825**.

Once an IAM with a valid ANI is determined, a table is entered which yields an OPC—DPC—CIC combination as shown in box **830**. One skilled in the art will recognize that

such a table can take many forms. One example is to set up a table with every combination of OPC—DPC—CIC on one side. The table is entered using the OPC—DPC—CIC of the incoming IAM message. After entry through these fields is accomplished, the table yields a new OPC—DPC—CIC which can be formulated into the SS7 message and sent to the switching network as shown in box **835**. The switching network is capable of using this information to make connections.

Once the IAM signal has been processed, subsequent SS7 messaging can be processed by a separate CIC look-up table entered using the CIC as shown in box **840**. Subsequent messages, such as address complete, answer, release, and release complete can be processed by entering the CIC table using the CIC in these non-IAM signals. For signals directed to the first point, the table yields the original OPC which is used as the DPC. Additionally, subsequent messages from the first point enter the CIC table using their CIC, and the table yields the DPC previously selected by the CCP for the IAM processing. The CIC table is constantly updated to reflect current processing as shown in box **845**. In this way, the CCP is able to efficiently process non-IAMs because theses signals only need to reflect the results of previous IAM selections.

There can be exceptions to the use of the CIC table for non-IAM call messages. One example would be if a new connection is allowed after release. In that case, the IAM procedures would be followed.

Those skilled in the art will recognize the numerous factors that can be used to design and load the tables. Different OPC—DPC—CIC combinations can be yielded by the tables based on many factors. Some of these factors are: called number, time of day, CPU occupancy, switch status, trunk status, automatic call distribution, operational control, error conditions, network alarms, user requests, and network element status.

For example, if a certain switch must be taken out of service, it is merely replaced in the table with suitable substitutes. The switch is then effectively taken out of service because it is no longer selected. If the CPU loading of a certain switch reaches a threshold, its presence in the tables can be diminished and distributed to other switches.

In another example, if it is busy hour in region A, the tables may yield network elements in region B to process the call. This can be accomplished by adding an area code or a dialed number entry, and time of day entry in the table. For calls placed from an OPC in region A to an area code or dialed number in region B, a narrowband switch in region B could be selected. As such, the DPC yielded by the table during this time frame should reflect a region B narrowband switch. Also, for calls placed from an OPC in region B to an area code or dialed number in region A, the tables should provide the DPC of a region B narrowband switch.

In a preferred embodiment, IAM messages would cause the CCP to query an SCP, data element, or database for support. The SCP would answer the query by using tables as discussed above. The answers would be sent to the CCP and used to formulate signaling. Subsequent messages would be then handled by the CCP using the CIC table. An example of such support would be for the CCP to query the SCP in response to receiving an IAM message. The query may include the OPC, CIC, DPC, and the area code, or dialed number. The SCP could use this information to select network characteristics and avoid busy regions as described in the above busy region example. For example, the SCP would maintain tables for OPC—dialed area code—time of day combinations that would yield a new DPC and CIC. This assumes that busy hour in a region corresponds to time of day, but other factors and yields could also be involved.

In one embodiment, the dialed number or area code could be used to select the new DPC, and time stamps could be placed in the signaling. This might entail tables with OPC—dialed area code entries that yield a new DPC and CIC. In this case, narrowband switches may not even be needed since billing can be applied using the time stamps. The CCP could then route the call directly using only the broadband network. This is especially relevant for POTS calls in which only an area code entry would need to be added to the tables.

As discussed above, often a connection will consist of two separate connection procedures. One connection procedure will be from the origination to a selected network element. The other connection procedure will be from the selected network element to the destination. Also it has been disclosed that the CCP could actually be discreet machines located regionally. In these cases, the CCP device processing the first connection procedure could be located in the origination region, and the CCP device that processes the second connection procedure could be located in the region of the selected network element.

The present invention offers the advantage of separating at least a portion of the communication control from the communication path. By examining and translating signaling independently of the communication path, multiple switches and network elements can be connected in the optimum way. Communications paths are no longer limited to only the connections the switches can control. Networks do not have to wait for standardization among signaling and interface protocols.

The present invention allows for the selection of network characteristics, such as network elements and connections, before switches process or apply the signaling. The switches are not required to have a capability either to make selections or to signal each other. The switches only make connections as directed by the CCP which signals in each switches own signaling format. Various criteria can be used for the selections in the CCP, such as time of day, load balancing, or invalid ANI. As such, the present invention allows for a smooth transition from narrowband to broadband networks. It also allows for the selection of network elements, such as servers and enhanced services platforms.

The present invention represents a fundamental and powerful departure from previous telecommunications technology. By separating the communications path from communication control, the CCP can utilize different networks and network devices intelligently. Previously, telecommunications systems have been dependent on the switches to accomplish communication control. As such, telecommunications systems have had to wait for the switches to develop communication control before new technology could be implemented. Switches have always been required to physically make connections and provide control over which connections are required. Switch capabilities have not been able to keep up with all of the network possibilities available. The result is a limited system.

Switches have been given support in this dual task. SCPs, STPs, and adjunct processors provide support for communication control. However, these devices only support the switches communication control, and the switch remains essential to communication control. This dependence has created a bottleneck given the available network possibilities.

One advantage of the present invention is that it allows narrowband switches be used interchangeably in a

narrowband/broadband hybrid network. Any narrowband switch may be taken out of service without re-routing traffic and changing routing logic in each switch. The CCP is simply programmed not to select the given narrowband switch for call processing. The CCP will route calls over the broadband network to another narrowband switch. This flexibility also allows the telecommunications network to easily transfer narrowband switch loads.

An important advantage of this system is that both the advantages of broadband and narrowband systems are utilized. The transmission capabilities of a broadband network are coupled with the narrowband network's ability to apply features. For example, the CCP can use the broadband network to substantially make the call connection from origination to destination. The CCP diverts the traffic to the narrowband network for processing. The narrowband network can apply features, such as billing and routing. Once processed, the traffic is directed back to the broadband network for completion of the connection. The CCP can then use the routing information generated by the narrowband system to route the traffic through the broadband system to the destination. As a result, the telecommunications system does not have to develop a billing or "800" routing feature for its broadband network. This can be accomplished because the CCP allows both networks to work together intelligently.

Another advantage of the present invention is the elimination of a substantial percentage of the DS0 ports required on the existing narrowband switches. In the current architectures, narrowband switches are interconnected to each other. A substantial percentage of the switch ports are taken up by these connections. By eliminating the need for the switches to connect to each other, these ports can be eliminated. Each narrowband switch is only connected to the broadband system. This architecture requires fewer ports per switch. By load balancing with the CCP, the number of ports required on busy switches can be reduced. The architecture in the present invention does require additional broadband ports, but these can be added at a significant cost saving versus narrowband ports.

Additionally, the narrowband switches no longer signal each other since all signaling is directed to the CCP. This concentration accounts for a reduction in required signaling link ports. This reduction possibly could result in the elimination of STPs.

As mentioned above, an advantage of the present invention is its ability to treat narrowband switches, or groups of narrowband switches, interchangeably. The CCP can pick any narrowband switch to process a particular call. This allows the network to pull narrowband switches out of service without taking extreme measures. In turn, this simplifies the introduction of new services into the network. A switch can be pulled out of service simply by instructing the CCP to stop selecting it. The switch can be re-programmed and put back into service. Then the next switch can then be updated in the same manner until all of the switches are implementing the new service. Switches can also be easily pulled to test developing applications.

This narrowband switch flexibility also allows the CCP to balance switch loads through the network during peak times, or during mass calling events. This eliminates the need to implement complex and expensive load balancing features in the narrowband network. Instead of programming the several switches to balance among themselves, one command to the CCP can achieve this.

Another advantage is the reduction in call set-up time. Most large networks require that a call pass through more than two narrowband switches arranged in a hierarchical fashion. One large network employs a flat architecture in which all narrowband switches are interconnected, but this still requires that the call pass through two narrowband switches. In the present invention, only one narrowband switch is required for each call. The use of broadband switches to set-up and complete the call represents significant time savings.

What is claimed is:

1. A method of transferring a user communication to a packet communication system, the method comprising:

receiving the user communication into a device;

receiving signaling formatted for a narrowband system into a processing system;

in the processing system, processing the signaling to select a network code that identifies a network element to provide egress for the user communication from the packet communication system;

transferring an instruction indicating the network code from the processing system to the device; and

transferring a packet including the network code and the user communication from the device to the packet communication system in response to the instruction.

2. The method of claim **1** wherein the user communication comprises a voice communication.

3. The method of claim **1** wherein receiving the user communication comprises receiving the user communication from a DS**0** connection.

4. The method of claim **1** wherein receiving the user communication comprises receiving the user communication from a communication path and wherein the processing system is not on the communication path.

5. The method of claim **1** wherein processing the signaling comprises processing SS7 signaling.

6. The method of claim **1** wherein processing the signaling comprises processing C7 signaling.

7. The method of claim **1** wherein processing the signaling comprises processing in-band signaling.

8. The method of claim **1** wherein processing the signaling comprises processing an Initial Address Message.

9. The method of claim **1** wherein processing the signaling comprises processing a called number.

10. The method of claim **1** wherein processing the signaling comprises processing a caller number.

11. The method of claim **1** further comprising, in the device, converting the user communication from one communication format to another communication format.

12. A method of transferring a user communication from a packet communication system, the method comprising:

receiving a packet including information and the user communication from the packet communication system into a device;

transferring the information from the device to a processing system;

in the processing system, processing the information to select a communication path;

transferring an instruction indicating the communication path from the processing system to the device;

transferring the user communication from the device to the communication path in response to the instruction; and

transferring signaling from the processing system wherein the signaling indicates the communication path for the user communication and is formatted for a narrowband system.

13. The method of claim **12** wherein the user communication comprises a voice communication.

14. The method of claim **12** wherein the communication path comprises a DS**0** connection.

15. The method of claim **12** wherein the communication path comprises a wireless connection.

16. The method of claim **12** wherein the communication path comprises an optical connection.

17. The method of claim **12** wherein the processing system is not on the communication path.

18. The method of claim **12** wherein processing the information comprises processing a called number.

19. The method of claim **12** wherein processing the information comprises processing a caller number.

20. The method of claim **12** wherein transferring the signaling comprises transferring SS7 signaling.

21. The method of claim **12** wherein transferring the signaling comprises transferring C**7** signaling.

22. The method of claim **12** wherein transferring the signaling comprises transferring in-band signaling.

23. The method of claim **12** wherein transferring the signaling comprises transferring an Initial Address Message.

24. The method of claim **12** further comprising, in the device, converting the user communication from one communication format to another communication format.

* * * * *

EXHIBIT D

US006452932B1

(12) **United States Patent**
Christie

(10) **Patent No.: US 6,452,932 B1**
(45) **Date of Patent: *Sep. 17, 2002**

(54) **METHOD, SYSTEM AND APPARATUS FOR TELECOMMUNICATIONS CONTROL**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **09/499,874**

(22) Filed: **Feb. 7, 2000**

Related U.S. Application Data

(63) Continuation of application No. 09/081,891, filed on May 20, 1998, which is a continuation of application No. 08/568,551, filed on Dec. 7, 1995, now Pat. No. 5,825,780, which is a continuation of application No. 08/238,605, filed on May 5, 1994, now abandoned.

(51) **Int. Cl.**[7] **H04L 12/28**; H04L 12/56
(52) **U.S. Cl.** **370/410**; 379/230
(58) **Field of Search** 370/395.1, 389, 370/396, 397, 398, 399, 400, 409, 410, 466, 467, 426, 422, 385, 386, 352–356; 379/229, 230, 231, 219, 221.1

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,201,889 A	5/1980	Lawrence et al.
4,348,554 A	9/1982	Asmuth
4,720,850 A	1/1988	Oberlander et al.
4,736,364 A	4/1988	Basso et al.
4,748,658 A	5/1988	Gopal et al.
4,763,317 A	8/1988	Lehman et al.
4,853,955 A	8/1989	Thorn et al.
4,979,118 A	12/1990	Kheradpir
4,991,204 A	2/1991	Yamamoto et al.

(List continued on next page.)

FOREIGN PATENT DOCUMENTS

CH	685033 A5	2/1995
DE	4225203 A1	12/1992
DE	4447230 A1	7/1995
EP	0403414 A2	12/1990
EP	0426911 A1	5/1991
EP	0442754 A2	8/1991

(List continued on next page.)

OTHER PUBLICATIONS

Ohta, S., et al., A Dynamically Controllable ATM Transport Network Based On The Virtual Path Concept, pp. 1272–1276, Communications For The Information Age, Globecom '88, Conference Record, vol. III, Nov. 28–Dec. 1, 1988.

Barr, W.J., et al., The TINA Initiative, IEEE Communications Magazine, vol. 31, No. 3, New York (US), pp. 70–76, Mar. 1993.

(List continued on next page.)

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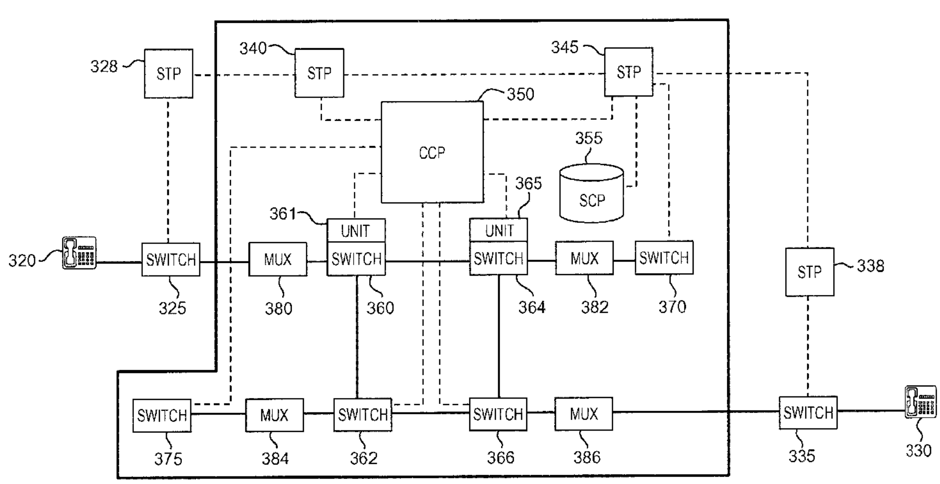
(57) **ABSTRACT**

The present invention includes a method, system, and apparatus for providing communication control. The invention includes a method in which signaling is processed externally to a switch before it is applied by the network elements. The processor is able to select network characteristics and signal the network elements based the selections. A network employing the processing method is also included, as well as a signaling system that employs the processing method.

34 Claims, 8 Drawing Sheets



U.S. PATENT DOCUMENTS

5,003,584 A		3/1991	Benyacar et al.	
5,048,081 A		9/1991	Gavaras et al.	
5,051,983 A		9/1991	Kammerl	
5,073,890 A		12/1991	Danielsen	
5,086,461 A		2/1992	Thorn et al.	
5,089,954 A		2/1992	Rago	
5,115,427 A	*	5/1992	Johnson, Jr. et al.	370/395
5,204,857 A		4/1993	Obara	
5,231,631 A		7/1993	Buhrke et al.	
5,239,542 A		8/1993	Breidenstein et al.	
5,251,255 A		10/1993	Epley	
5,282,244 A		1/1994	Fuller et al.	
5,291,492 A		3/1994	Andrews et al.	
5,327,421 A		7/1994	Hiller et al.	
5,345,445 A		9/1994	Hiller et al.	
5,345,446 A		9/1994	Hiller et al.	
5,365,524 A		11/1994	Hiller et al.	
5,373,504 A		12/1994	Tanaka et al.	
5,375,124 A		12/1994	D'Ambrogio et al.	
5,377,186 A		12/1994	Wegner et al.	
5,384,771 A		1/1995	Isidoro et al.	
5,394,393 A		2/1995	Brisson et al.	
5,420,857 A		5/1995	Jurkevich	
5,420,858 A		5/1995	Marshall et al.	
5,420,916 A		5/1995	Sekiguchi	
5,422,882 A		6/1995	Hiller et al.	
5,425,090 A		6/1995	Orriss	
5,426,636 A		6/1995	Hiller et al.	
5,428,607 A		6/1995	Hiller et al.	
5,434,852 A		7/1995	La Porta et al.	
5,434,981 A		7/1995	Lenihan et al.	
5,440,563 A		8/1995	Isidoro et al.	
5,444,713 A		8/1995	Backaus et al.	
5,448,569 A		9/1995	Huang et al.	
5,452,297 A		9/1995	Hiller et al.	
5,453,981 A		9/1995	Katsube et al.	
5,461,669 A		10/1995	Vilain	
5,473,677 A		12/1995	D'Amato et al.	
5,473,679 A		12/1995	La Porta et al.	
5,495,484 A		2/1996	Self et al.	
5,509,010 A	*	4/1996	La Porta et al.	370/410
5,513,355 A		4/1996	Doellinger et al.	
5,519,707 A		5/1996	Subramanian et al.	
5,526,359 A	*	6/1996	Read et al.	370/410
5,539,884 A		7/1996	Robrock, II	
5,550,834 A		8/1996	D'Ambrogio et al.	
5,579,311 A		11/1996	Chopping et al.	
5,600,640 A		2/1997	Blair et al.	
5,673,262 A		9/1997	Shimizu	
5,703,876 A		12/1997	Christie	
5,825,780 A		10/1998	Christie	
6,016,343 A		1/2000	Hogan et al.	

FOREIGN PATENT DOCUMENTS

EP	0460843 A2	12/1991
EP	0466078 A2	1/1992
EP	0482773 A1	4/1992
EP	0539016 A2	4/1993
EP	0549016 A1	6/1993
EP	0582418 A2	2/1994
EP	0592152 A2	4/1994
EP	592153 A2	4/1994
EP	592154 A2	4/1994
EP	0608584 A1	8/1994
EP	0650281 A1	4/1995
FR	2616 025 A1	12/1988
FR	2714559 A1	6/1995
SU	1515172 A1	10/1989
SU	18064444 A3	3/1993
WO	WO 92/14321	8/1992
WO	WO 93/18598	9/1993
WO	WO 94/05121	3/1994
WO	WO 94/06251	3/1994

OTHER PUBLICATIONS

Chen, S., et al., Intelligent Networking For The Global Marketplace, IEEE Communications Magazine, vol. 31, No. 3, Mar. 1993, New York (US), pp. 86–92.

Fujioka, M., et al., Hierarchical And Distributed Information Handling For UPT, IEEE Network Magazine, Nov. 1990.

Fujioka, M., et al., "Universal Service Creation and Provision Environment For Intelligent Network," IEEE Communications Magazine, Jan. 1991.

Garrahan, J.J., et al., "Intelligent Network Overview," pp. 30–36, IEEE Communications Magazine, Mar. 1993.

Gilmour, J., et al., Intelligent Network/2: The Architecture—The Technical Challanges—The Opportunities, IEEE Communications Magazine, vol. 26, No. 12, Dec. 1988, New York (US) pp. 8–11 and 63.

Weisser, F.J., et al., The Intelligent Network And Forward–Looking Technology, IEEE Communications Magazine, vol. 26, No. 12, Dec. 1988, New York (US), pp. 64–69, Dec., 1988.

General Recommendations On Telephone Switching And Signaling Intelligent Network—Intelligent Network Distributed Functional Plane Architecture, Q.1204, ITU–T—Mar. 1993.

General Recommendations On Telephone Switching And Signaling Intelligent Network—Intelligent Network Physical Plane Architecture Q. 1205, ITU–T Recommendation, Telecommunication Standardization Sector of ITU.

General Recommendations On Telephone Switching And Signaling—Intelligent Network/Distributed Functional Plane For Intelligent Network CS–1, ITU–T Recommendation Q. 1214, ITU—Telecommuncation Standardization Sector.

Rec. I. 312, "ISDN—Principles Of Intelligent Network Architecture." ITU—Telecommunication Standardization Sector, Oct. 1992.

"Report Of The Meeting of SWP 13/1–4", Study Group 13, Temporary Document 46 (13/1), ITUT, Mar. 1994.

"Interworking B–ISUP and Q.93B for DDI, MSN, TP and SUB", Study Group 11, Temporary Document 2/ll–131l, ITU–Telecommunication Standardization Sector, Nov. 29–Dec. 17, 1993.

"Final B–ISUP SDLS", Study Group 11, Temporary Document 11/2–53–C, ITU—Telecommunication Standardization Sector, Nov. 29—Dec. 17, 1993.

"Annexes B, C, D, F, H and I OF Q.2931", Study Group 11, Temporary Document 2/ll–27 C, ITU—Telecommunication Standardization Sector, Nov. 29–Dec. 17, 1993.

McKinney, Scott, "ATM for Narrowband Services" IEEE Communications Magazine, Apr., 1994, New York, US, pp. 64–72.

Palmer, Rob, "An Experimental ATM Network Featuring Decoupled Modular Control," Telecom Australia Research Laboratories (Victoria), pp. 118–122 (Nov., 1992).

ITU–T Q.1208, General Aspects of the Intelligent Network Application Protocol, ITU–T Recommendation Q. 1208.

ITU–T Q.1218 Addendum 1, Series Q: Switching and signaling Intelligent Network, Interface Recommendations for Intelligent Network CS–1, Addendum 1: Definition for two new contexts in the SDF data model.

* cited by examiner

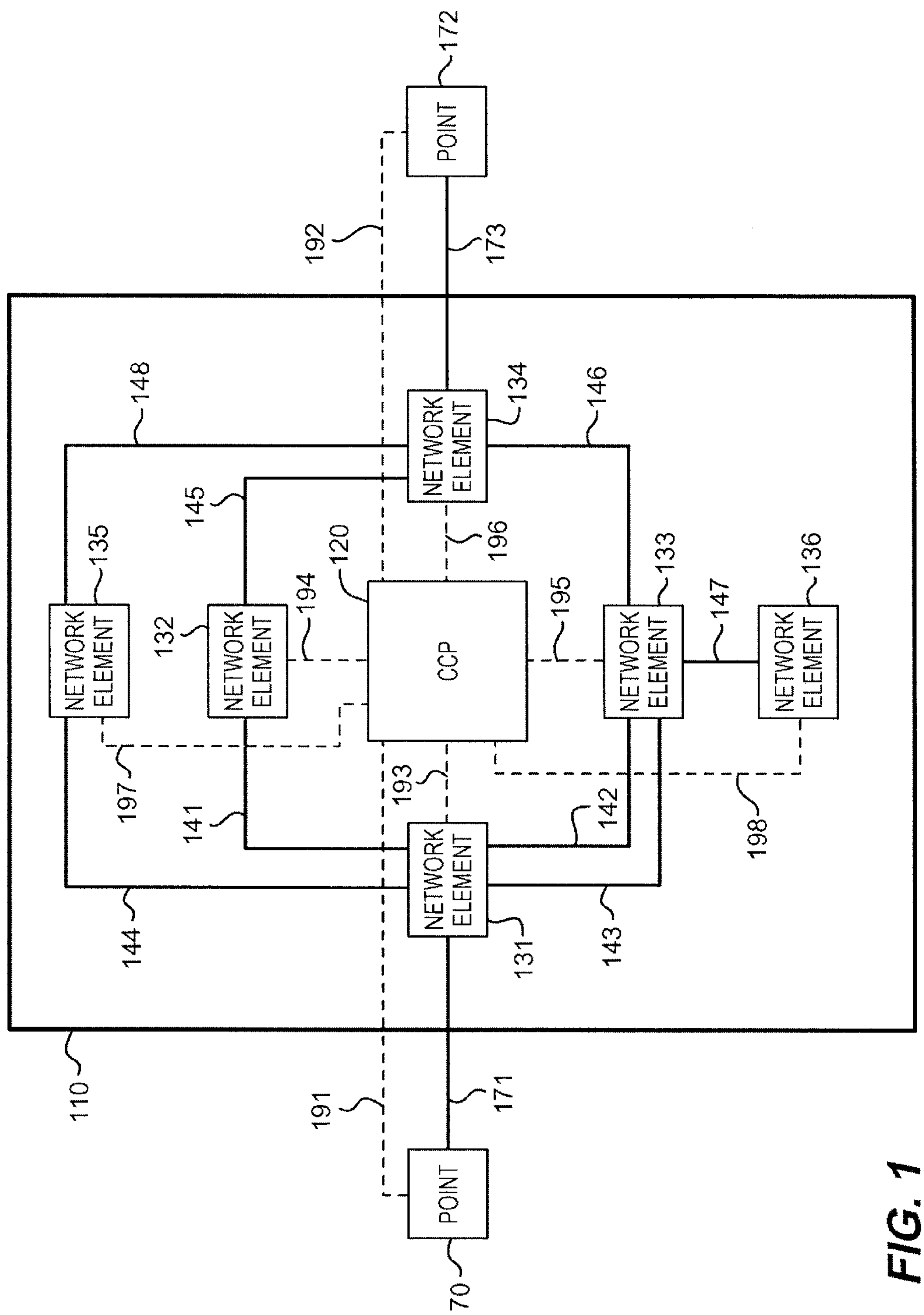

172
POINT
192
173
148
NETWORK ELEMENT
134
146
145
120
196
135
NETWORK ELEMENT
132
NETWORK ELEMENT
194
CCP
195
NETWORK ELEMENT
133
147
NETWORK ELEMENT
136
197
193
141
142
198
NETWORK ELEMENT
144
131
143
110
191
171
POINT
170

FIG. 1

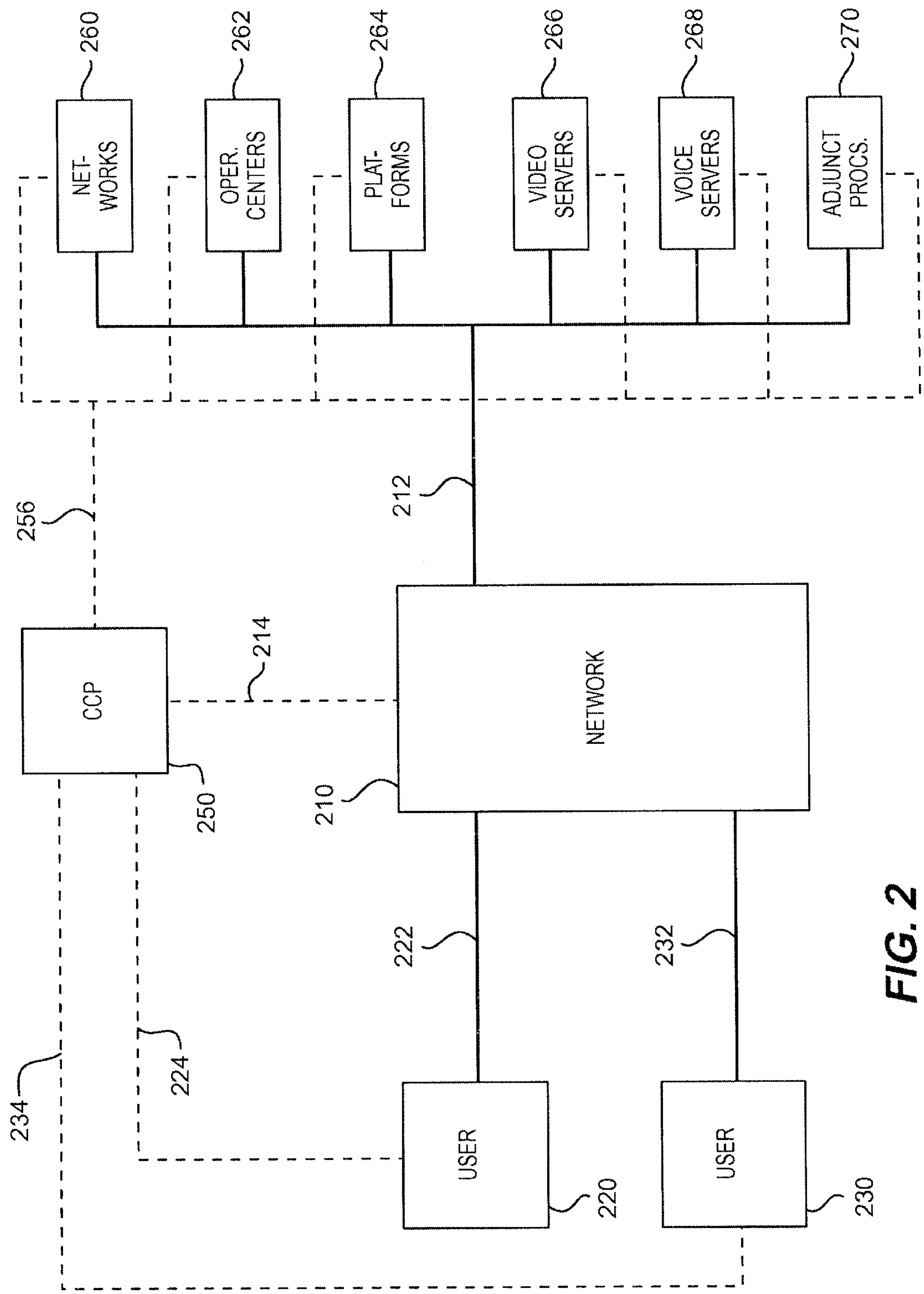

260
NET-WORKS
262
OPER. CENTERS
264
PLAT-FORMS
266
VIDEO SERVERS
268
VOICE SERVERS
270
ADJUNCT PROCS.
256
212
CCP
214
250
NETWORK
210
222
232
234
224
USER
220
USER
230

FIG. 2

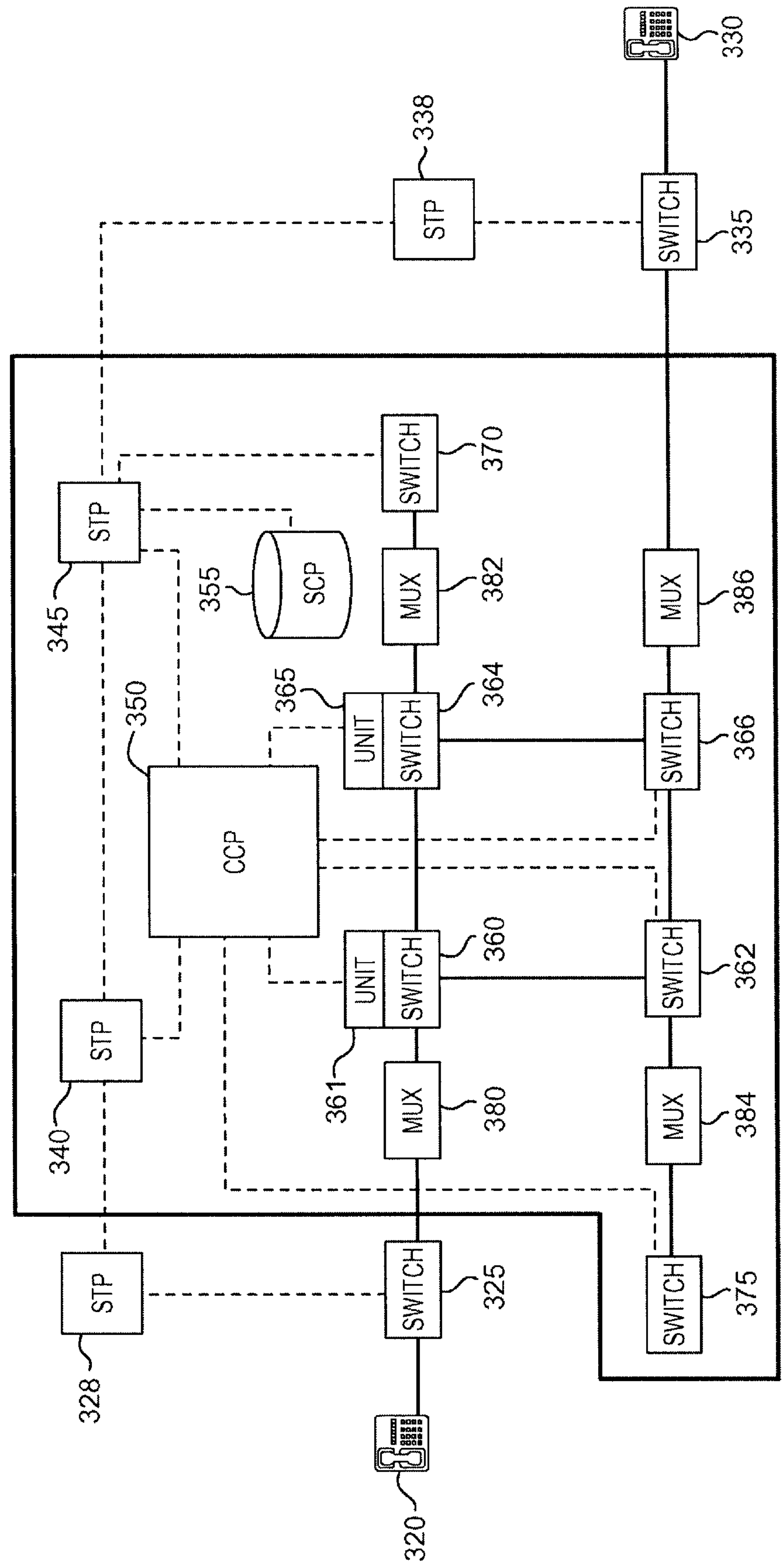

330
338
STP
SWITCH
335
STP
345
SWITCH
370
SCP
355
MUX
382
MUX
386
350
365
UNIT
SWITCH
364
SWITCH
366
CCP
UNIT
SWITCH
360
SWITCH
362
STP
340
361
MUX
380
MUX
384
STP
328
SWITCH
325
SWITCH
375
320

FIG. 3

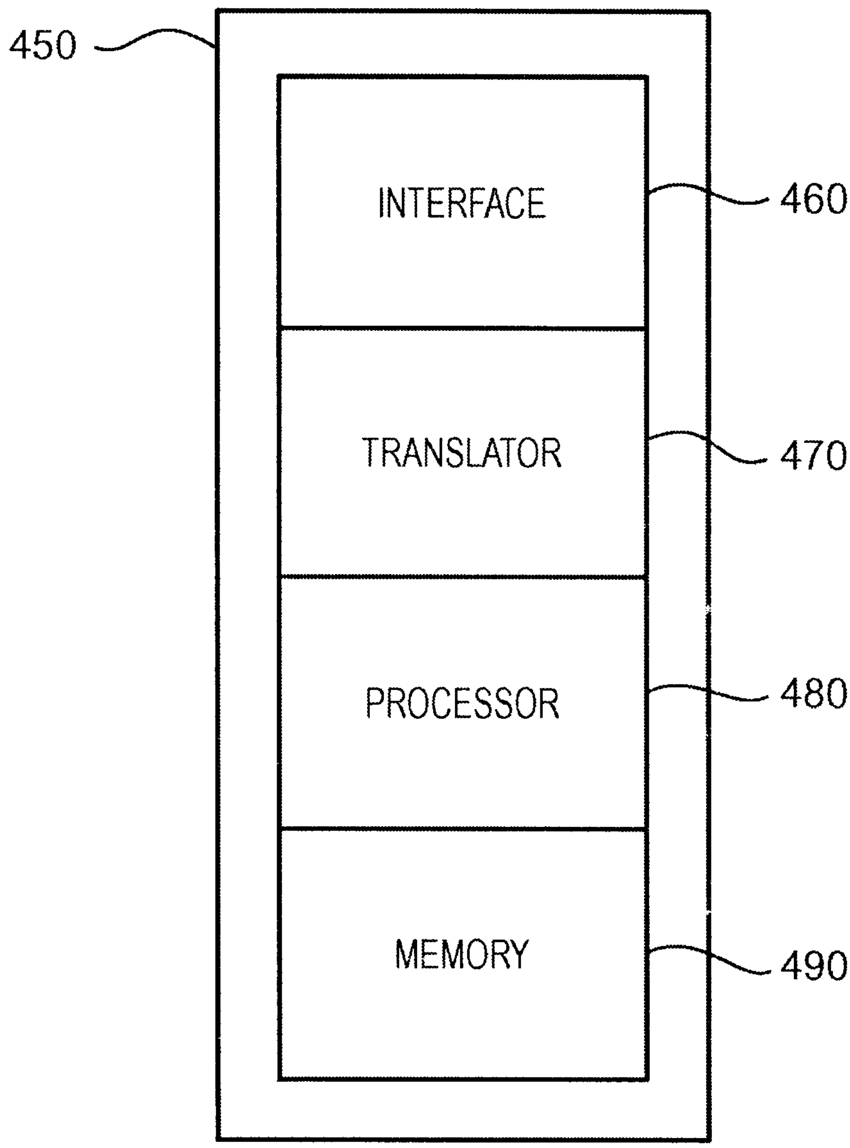


FIG. 4

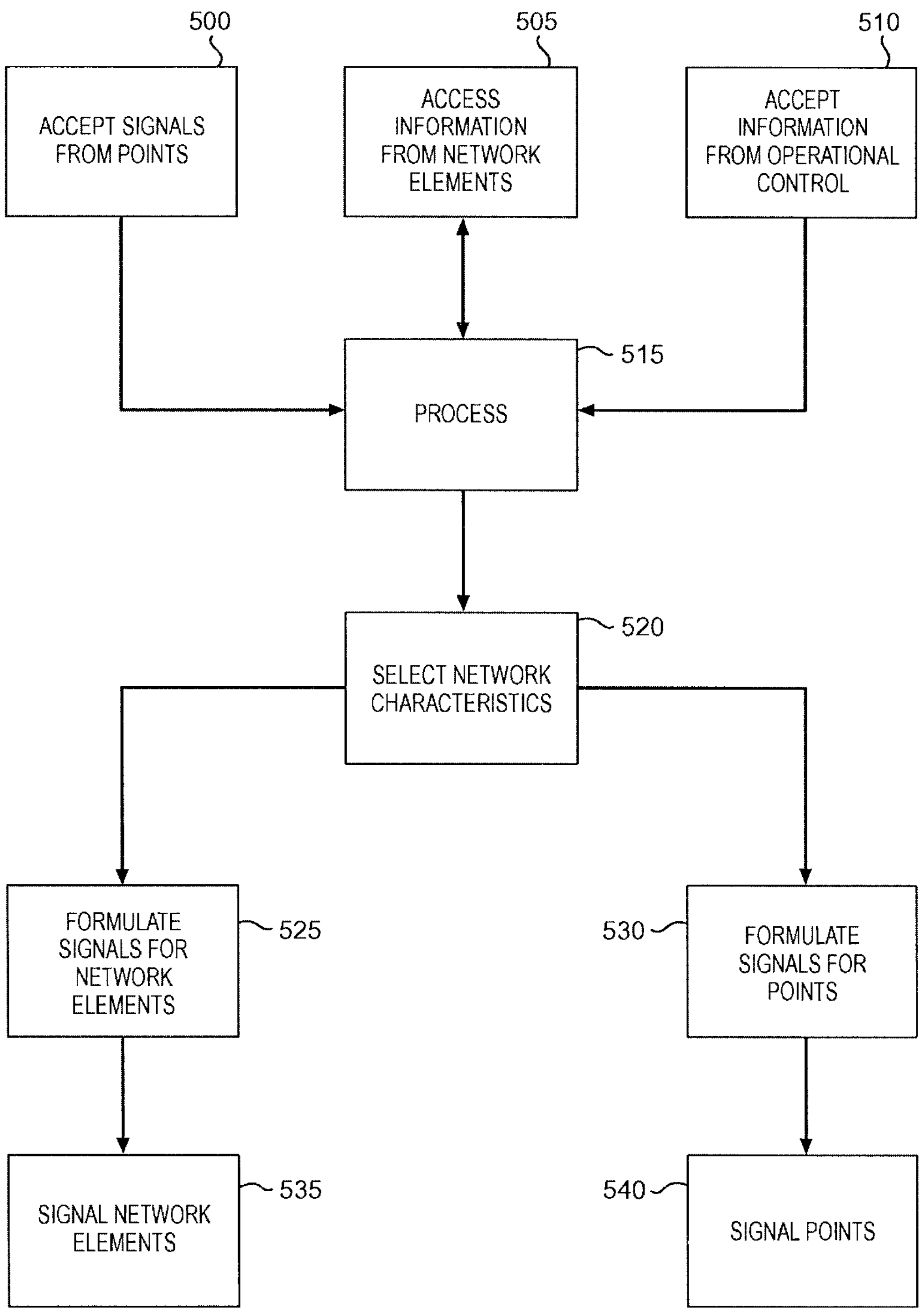

500
ACCEPT SIGNALS FROM POINTS
505
ACCESS INFORMATION FROM NETWORK ELEMENTS
510
ACCEPT INFORMATION FROM OPERATIONAL CONTROL
515
PROCESS
520
SELECT NETWORK CHARACTERISTICS
525
FORMULATE SIGNALS FOR NETWORK ELEMENTS
530
FORMULATE SIGNALS FOR POINTS
535
SIGNAL NETWORK ELEMENTS
540
SIGNAL POINTS

FIG. 5

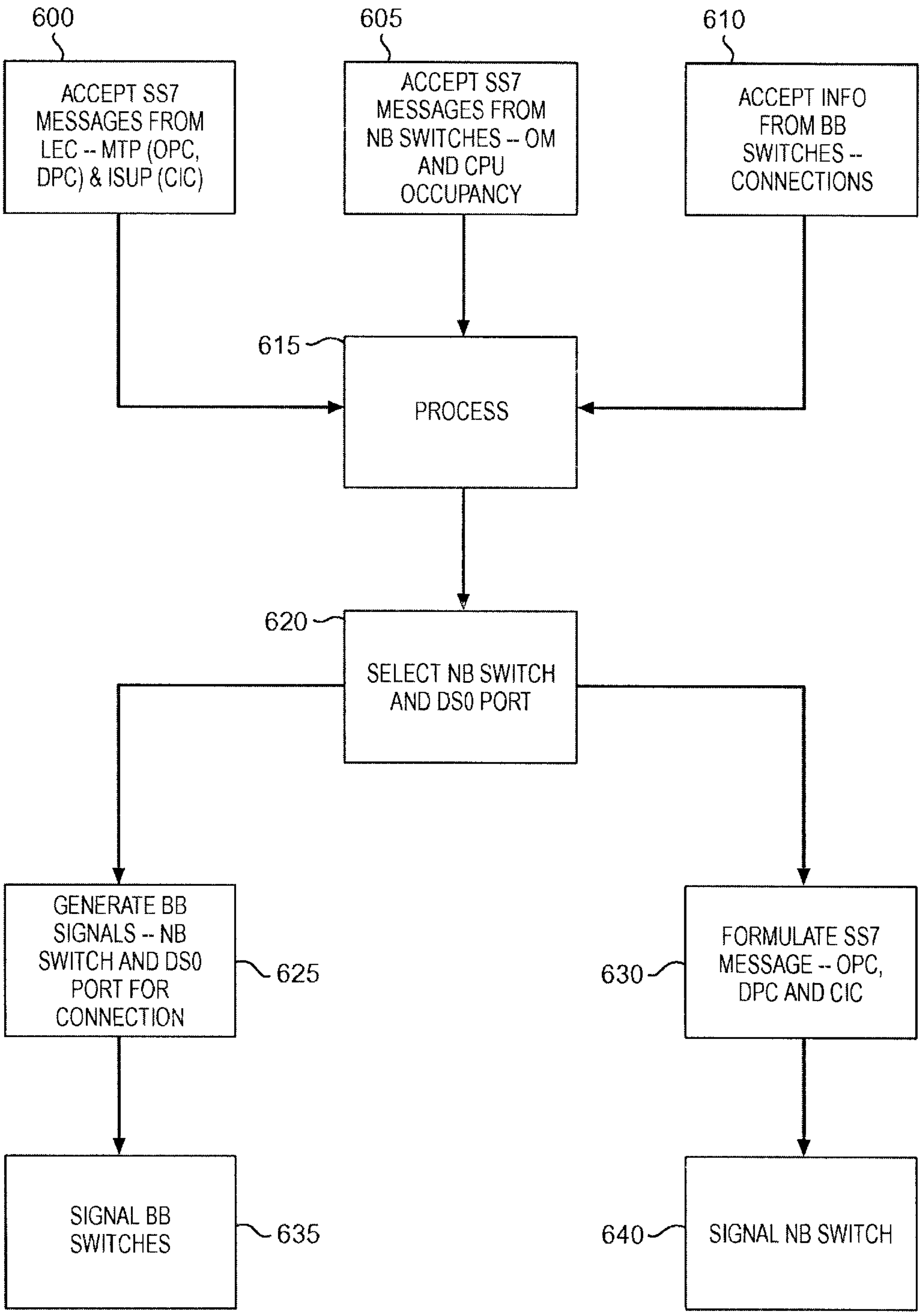

600
ACCEPT SS7 MESSAGES FROM LEC -- MTP (OPC, DPC) & ISUP (CIC)
605
ACCEPT SS7 MESSAGES FROM NB SWITCHES -- OM AND CPU OCCUPANCY
610
ACCEPT INFO FROM BB SWITCHES -- CONNECTIONS
615
PROCESS
620
SELECT NB SWITCH AND DS0 PORT
GENERATE BB SIGNALS -- NB SWITCH AND DS0 PORT FOR CONNECTION
625
630
FORMULATE SS7 MESSAGE -- OPC, DPC AND CIC
SIGNAL BB SWITCHES
635
640
SIGNAL NB SWITCH

FIG. 6

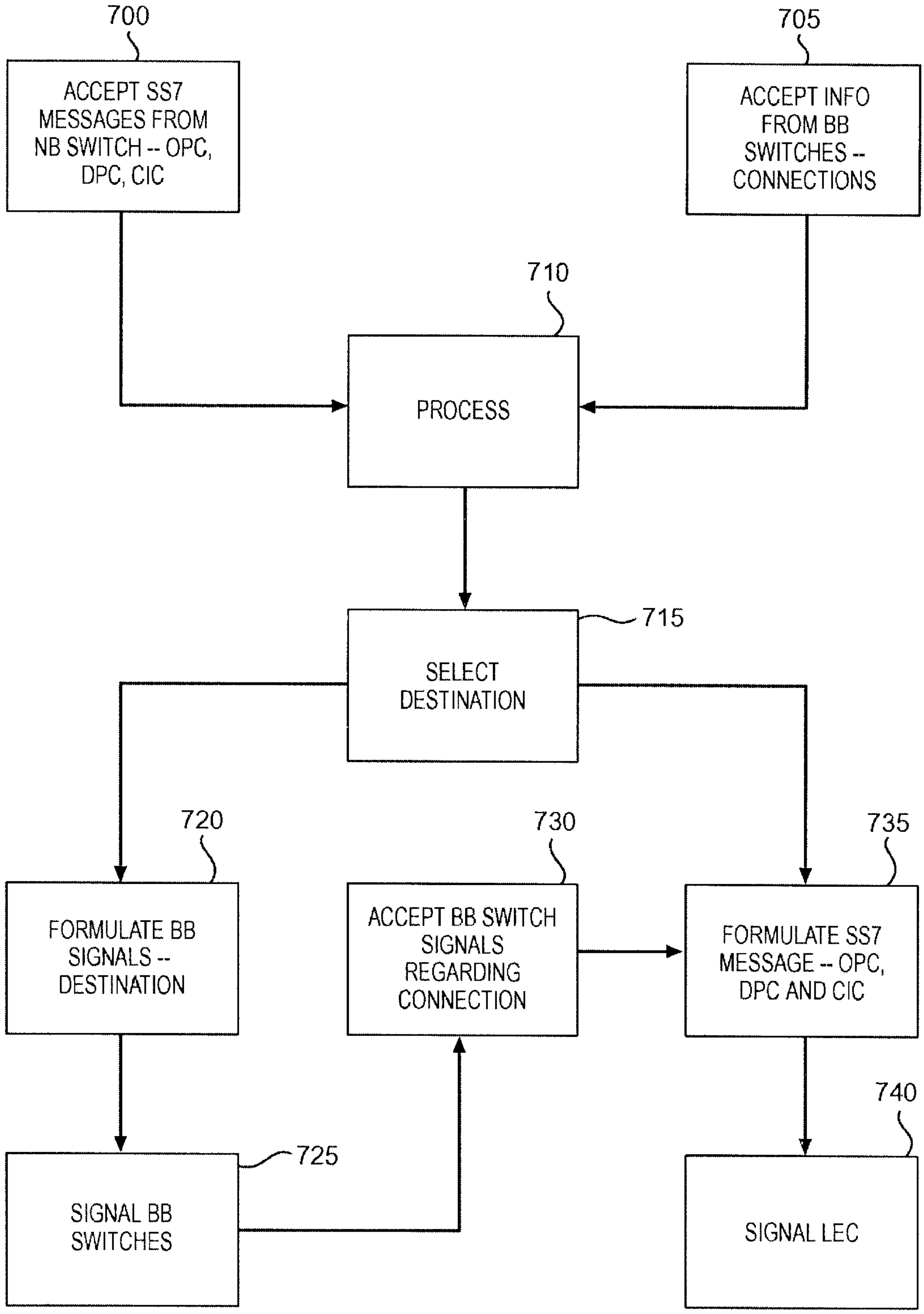

700
ACCEPT SS7 MESSAGES FROM NB SWITCH -- OPC, DPC, CIC
705
ACCEPT INFO FROM BB SWITCHES -- CONNECTIONS
710
PROCESS
715
SELECT DESTINATION
720
FORMULATE BB SIGNALS -- DESTINATION
730
ACCEPT BB SWITCH SIGNALS REGARDING CONNECTION
735
FORMULATE SS7 MESSAGE -- OPC, DPC AND CIC
725
SIGNAL BB SWITCHES
740
SIGNAL LEC

FIG. 7

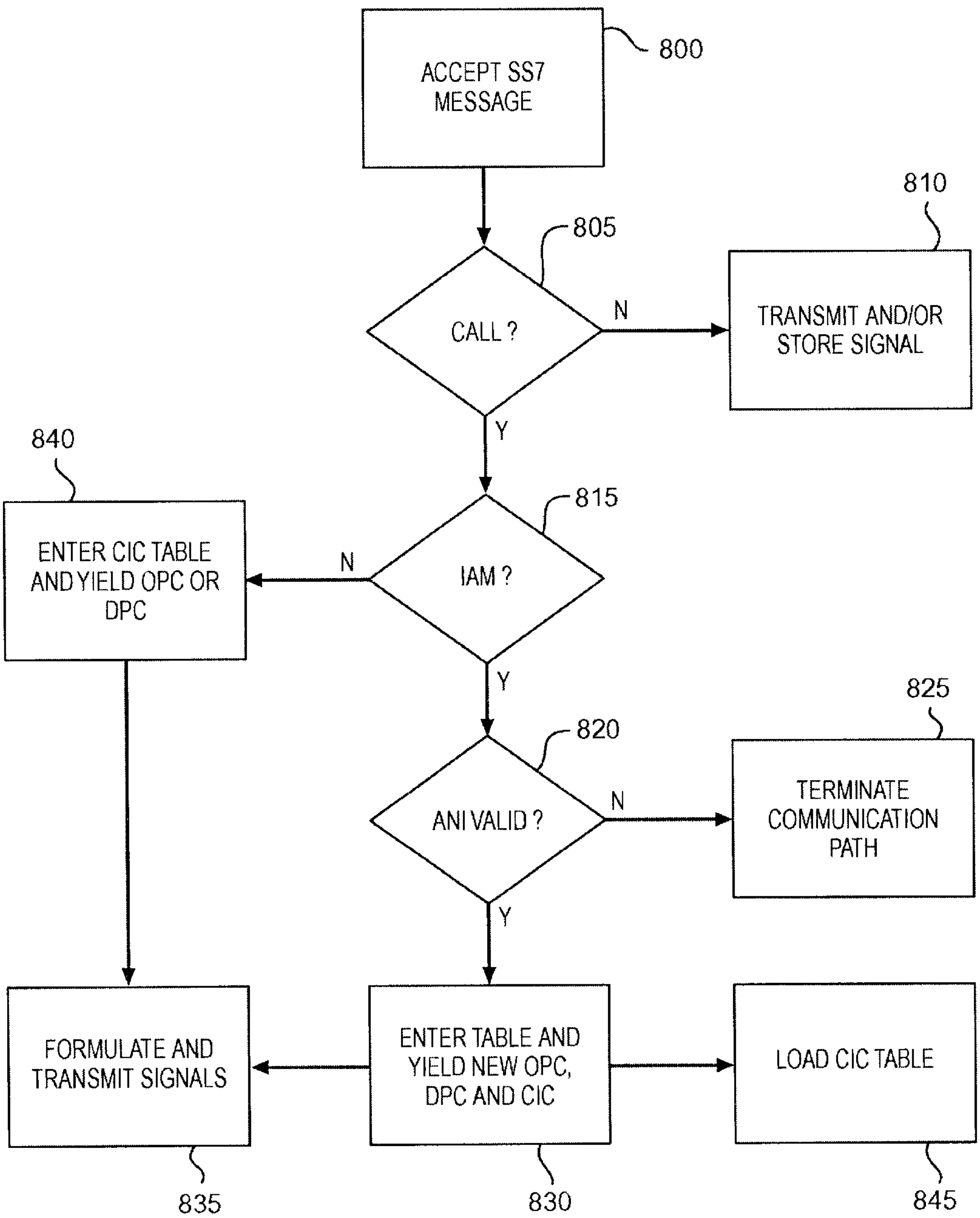

ACCEPT SS7 MESSAGE
800
CALL ?
805
N
Y
TRANSMIT AND/OR STORE SIGNAL
810
IAM ?
815
N
Y
ENTER CIC TABLE AND YIELD OPC OR DPC
840
ANI VALID ?
820
N
Y
TERMINATE COMMUNICATION PATH
825
FORMULATE AND TRANSMIT SIGNALS
835
ENTER TABLE AND YIELD NEW OPC, DPC AND CIC
830
LOAD CIC TABLE
845

FIG. 8

METHOD, SYSTEM AND APPARATUS FOR TELECOMMUNICATIONS CONTROL

RELATED APPLICATIONS

This application is a continuation of application Ser. No. 09/081,891, filed on May 20, 1998, which is a continuation of U.S. patent application Ser. No. 08/568,551 filed Dec. 7, 1995, issued on Oct. 20, 1998, now U.S. Pat. No. 5,425,780, which is a continuation of U.S. patent application No. 08/238,605 filed May 5, 1994 and now abandoned; and which are all hereby incorporated by reference into this application.

FEDERALLY SPONSORED RESERCH OR DEVELOPMENT

Not applicable

MICROFICHE APPENDIX

Not applicable

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to telecommunications and more specifically to communications control processing in telecommunications signaling.

2. Description of the Prior Art

Telecommunications systems establish a communications path between two or more points to allow the transfer of information between the points. The communications path typically comprises a series of connections between network elements. The network elements are typically switches. Switches provide the primary means where different connections are associated to form the communications path.

Communication control is the process of setting up a communications path between the points. Communication control comprises the selection of network elements such as switches or other devices which will form part of the communications path. Communication control also comprises the selection of the connections between the network elements. Together, the network elements and connections which are selected make up the communications path. Typically, a plurality of different network element and connection selections may be possible for any one communications path between points.

Switches control these selections. Switches select the connections that comprise the communications path. Switches also select the network elements which form an actual part of that communications path. By selecting these network elements, a switch is often selecting the next switch that will make further selections. Switches accomplish communication control.

The correspondence between communication control and a communications path is well known in the art. A common method used in communication control is signaling among switches. One method by which a first point requests a communications path to a second point is by signaling a first switch with an off-hook signal followed by dual tone multifrequency (DTMF) signals. The first switch will typically process those signals and will select other network elements such as a second switch. The first switch signals the second switch and establishes a connection between the switches. The second switch then selects the next network element, signals that network element, and establishes a connection to that network element. This process is well known in the art.

The connections and signaling thus proceed from switch to switch through the network until a communications path is established between the first and second points.

Some networks transmit signaling information from the switches to other signaling devices. In these cases, the switches typically must be modified through the use of Signaling Point (SP) hardware and software in order to convert the language of the switch into the language used by these other signaling devices. One signaling device is a Service Control Point (SCP). An SCP processes signaling queries from a switch. An SCP only answers a switch query after the switch has become a part of the communications path. SCPs support the communication control which is directed by the switch.

Additionally, signaling may pass through other signaling devices, such as Signal Transfer Points (STPs), which route the signaling. An STP is typically a high-speed packet data switch which reads portions of the signaling information and either discards or routes the information to a network element. The signal routing operation of the STP is based on the signaling information that is specified by the switch. STPs route signaling information, but STPs do not modify or otherwise process the signaling information. An example of the above described system is Signaling System #7 (SS7) technology. Thus, signaling devices only are used to support switches in communication control.

Broadband systems, such as Asynchronous Transfer Mode (ATM) may use extensions of existing SS7 signaling to allow ATM switches to direct communication control. However, broadband systems may also utilize different communication control methods. ATM switches may transfer ATM cells which contain signaling to other ATM switches. As with the other switch types however, ATM switches also perform the dual task of communication control and forming a part of the communications path.

Some switches use API switching which employs remote central processing units (CPUs). These switches only receive switch information from the remote CPUs and not signaling. The protocols used for information transfer between the switch and the remote CPU are proprietary among vendors and are incompatible between the switches of different vendors.

Some digital cross-connect (DCS) equipment employ centralized control systems. These systems, however, only provide relatively static switching fabrics and do not respond to signaling. Instead of establishing connections in response to signaling, DCS cross-connections are established in response to network configuration needs. Network elements and connections are pre-programmed into the network and are not selected in response to signaling from a point outside of the network.

At present, while communication control and the communications path are distinct from one another, both are dependent on the switch. The performance of both of these tasks by switches places limitations on a telecommunications network. One such limitation can be illustrated by one difficulty encountered in combining narrowband networks and broadband networks. Broadband networks are advantageous for data transmission because virtual permanent connections can be mapped through a network and bandwidth allocated on demand. Narrowband switches are advantageous for voice, in part, due to the many features which have been developed in conjunction with these switches. These features benefit both the user and the network through added efficiency and quality. Examples are "800" platforms, billing systems, and routing systems. However for broadband

networks, the development of these features is incomplete and does not provide the functionality of current narrowband features. Unfortunately, narrowband switches do not have the capacity, speed, and multimedia capabilities of broadband switches. The resulting combination is separate overlay networks. Typically, narrowband traffic remains within the narrowband network, and broadband traffic remains within the broadband network.

Any intelligent interface between the two networks would require that signaling information be transmitted between narrowband switches and broadband switches. At present, the ability of these switches to signal each other is limited. These switch limitations create a major obstacle in any attempt to interface the two networks. It would be advantageous if narrowband and broadband networks could interwork through an intelligent interface to establish a communications path between points. At present, the interface between narrowband and broadband networks remains a rigid access pipe between overlay systems.

The reliance on switches to both perform communication control and to form the a part of the communications path results in impediments to developing improved networks. Each time a new network element, such as a broadband switch, is introduced, a telecommunications network may be forced to delay integrating the network element into its network until standardization of signaling and interface protocols are developed for the switches. At present, there is a need for a portion of the communication control processing to be independent of the switches that form a part of the communications path.

SUMMARY

An embodiment of the present invention solves this need by providing a method, system, and apparatus for communication control processing that is located externally to the switches that make the connections. The method includes receiving a first signal into a processor which is located externally to the switches in a network comprised of network elements. The processor selects a network characteristic in response to the first signal. The processor then generates a second signal reflecting the network characteristic and transmits the second signal to at least one network element. This transmission occurs before that network element has applied the first signal. Examples of network characteristics are network elements and connections, but there are others. Examples of signaling are Signaling System #7 or broadband signaling. The processor may also employ information received from the network elements or operational control when making selections. In one embodiment, the method includes receiving the first signal into a network from a point and routing the first signal to the processor.

The present invention also includes a telecommunications processing system which comprises an interface that is external to the switches and is operational to receive and transmit signaling. The processing system also includes a translator that is coupled to the interface and is operational to identify particular information in the received signaling and to generate new signaling based on new information. The processor also includes a processor that is coupled to the translator and is operational to process the identified information from the translator in order to select at least one network characteristic. The processor provides new information to the translator reflecting the selection. The identified information is used in the processor before it is used in the particular network elements that receive the new signaling.

The present invention also includes a telecommunications network comprised of a plurality of network elements wherein at least one network element is a switch, and a plurality of connections between the network elements. The network also includes a processor located externally to the switches which is operable to receive a first signal, to select at least one network characteristic in response to the first signal, and to generate a second signal reflecting the selection. The network also includes a plurality of links between the processor and the network elements which are operable to transmit the second signal to at least one network element before that network element has applied the first signal.

The present invention also includes a telecommunications signaling system for use in conjunction with a plurality of telecommunication switches. This system comprises a plurality of signaling points and a signaling processor. The signaling processor is linked to the signaling points and resides externally to the switches. The signaling processor is operational to process signaling and to generate new signaling information based on the processing. The new signaling is transmitted over the links to multiple signaling points. In one embodiment, the new signaling information is comprised of different signaling messages and the different signaling messages are transmitted to different signaling points.

In another embodiment, a plurality of the signaling points each reside in a different switch and are directly coupled to a processor in the switch that directs a switching matrix in the switch in response to signaling processed by the signaling point. The signaling processor is operational to direct the switching matrixes of multiple switches by signaling multiple signaling points. The signaling processor is also operational to signal multiple points in response to signaling from a single source, and to signal a point in response to signaling from multiple sources.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features, aspects, and advantages of the present invention will become better understood with regard to the following description, claims, and drawings where:

FIG. **1** is a block diagram of a version of the invention.

FIG. **2** is a block diagram of a version of the invention.

FIG. **3** is a block diagram of a version of the invention.

FIG. **4** is a logic diagram of a version of the invention.

FIG. **5** is a flow diagram of a version of the invention.

FIG. **6** is a flow diagram of a version of the invention.

FIG. **7** is a flow diagram of a version of the invention.

FIG. **8** is a flow diagram of a version of the invention.

DESCRIPTION

Telecommunications systems establish communications paths between points which allow the points to transfer information, such as voice and data, over the communication paths. Typically, telecommunications systems are comprised of network elements and connections. A network element is a telecommunications device such as a switch, server, service control point, service data point, enhanced platform, intelligent peripheral, service node, adjunct processor, network element of a different network, enhanced system or other network related device, server, center or system.

A connection is the media between two network elements that allows the transfer of information. A few examples of connections are: digital T1 lines, OC-3 optical fibers, packet connections, dedicated access lines, microwave

transmission, and cellular radio. As those skilled in the art are aware, connections can be described in a range from general to specific. All of the media between two switches is a general description and might correspond to a virtual path in an ATM system or a trunk groups in a T1 system. An individual circuit between two elements is more specific and might correspond to a virtual channel in an ATM system or a DS0 circuit in a T1 system. Connections can also be described as being logical or physical. Physical connections are electrical-mechanical media. Logical connections are paths which follow physical connections, but are differentiated from one another based on format and protocol. The term "connection" includes this entire range and the meaning varies according to the context in which the term is used. The present invention could make selections encompassing the entire range of connections.

A communications path is the combination of connections and network elements that physically transfers the information between points. A communication path may be point to point, point to multi-point, or multi-point to multi-point. These points, in turn, define the ends of the communications path. Thus, a connection may also be made between a network element and a point outside the network.

Signaling is the transfer of information among points and network elements and is used to establish communications paths. An example is Signaling System #7 (SS7). Signaling is typically transmitted over links, such as 56 kilobit lines. On the block diagrams, signaling is represented by dashed lines and connections are represented by solid lines.

In FIG. **1**, Telecommunications System **110** comprises a communication control processor (CCP) **120** and first, second, third, fourth, fifth and sixth network elements, **131**, **132**, **133**, **134**, **135** and **136** respectively. First and second network elements, **131** and .**132** respectively, are connected by first connection **141**. First and third network elements, **131** and **133** are connected by both second and third connections, **142** and **143** respectively. First and fifth network elements, **131** and **135** respectively, are connected by fourth connection **144**. Second and fourth network elements, **132** and **134** are connected by fifth connection **145**. The third network element **133** is connected to fourth and sixth network elements, **134** and **136** by sixth and seventh connections, **146** and **147** respectively. Fourth and fifth network elements, **134** and **135** are connected by connection **148**. A first point **170**, which is located outside of the system **110**, is connected to first element **131** by first point connection **171**, and a second point **172** which is also located outside the system **110** is connected to fourth element **134** by second point connection **173**. First and second points, **170** and **172** respectively and first, second, third, fourth, fifth and sixth elements **131**, **132**, **133**, **134**, **135**, and **136** respectively each are linked to CCP **120** by first, second, third, fourth, fifth, sixth, seventh, and eighth links, **191**, **192**, **193**, **194**, **195**, **196**, **197** and **198** respectively.

As those skilled in the art are aware, a system is typically comprised of many more network elements, links, connections and points, but the number is restricted for clarity. Points outside of the network can take many forms, such as customer premises equipment (CPE), telephones, computers, or switches of a separate network system. In addition the system **110**, may take many forms such as international gateways, satellite networks, wireless networks, local exchange carriers (LECs), inter-exchange carriers (IXCs), transit networks, national networks, personal communicator systems (PCS), virtual private networks, or connection oriented networks such as local area networks (LANs), metropolitan area networks (MANs), wide area networks (WANs) to name some examples.

In operation Telecommunications System **110** is able to accept information from first point **170** and second point **172** and transmit the information over the various network elements and connections which form the communications path. System **110** is also capable of exchanging signaling with first point **170** and second point **172** over the first link **191** and second link **192**.

On a standard call that establishes a communications path from first point **170** to second point **172**, first point **170** will signal Telecommunications System **110** that it requests the communications path. This signaling is directed to CCP **120** over first link **191**. CCP **120** processes the signaling and selects at least one network characteristic in response to the signaling. Network characteristics might be network elements, connections, network codes, applications, or control instructions to name a few examples. The selected network characteristic typically comprises one of a plurality of network elements and/or connections. The CCP **120** generates signaling which is preferably new signaling reflecting the selection. CCP **120** then transmits the signal to at least one of a plurality of network elements before that network element has applied the signal.

In one embodiment, CCP **120** selects the network elements and the connections that comprise the communications path. However, first point **170** will typically seize first point connection **171** contemporaneously with signaling. This initial connection could also be selected by CCP **120** from the available possibilities after the signaling by first point **170**. Assuming first point **170** has seized first point connection **171** to first element **131**, CCP **120** selects one, a plurality, or all of the remaining network elements and connections to further establish a communications path to second point **172**.

CCP **120** determines which element should be connected to first element **131**. CCP **120** could select either second element **132** or third element **133**. If third element **133** is selected, CCP **120** may also select the connection to third element **133** from among second and third connections, **142** and **143** respectively. If third connection **143** is selected, CCP **120** will signal first element **131** over third link **193** to further the communications path to third element **133** over third connection **143**.

CCP **120** may then make further selections to complete the communications path. As the possibilities have been limited for clarity, CCP **120** would make the selections and signal the elements as follows. CCP **120** would signal third element **133** over fifth link **195** to further the communications path to fourth element **134** over sixth connection **146**. CCP **120** would signal fourth element **134** over sixth link **196** to further the communications path to second point **172** over second point connection **173**. CCP **120** would also signal second point **172** over second link **192** of the communications path available through second point connection **173**. In this way, the communications path requested by first point **170** is selected by CCP **120** and signaled to the elements. Throughout this process, CCP **120** may receive status messages and signaling from the elements to support its processing. This status messaging may be transmitted and received over links, connections, or other communication means.

In another embodiment, CCP **120** may select only the network elements and not the connections. The elements would select the connections to use based on the network element selected by CCP **120**. For this embodiment, the main difference from the above example is that CCP **120** would instruct first element **131** to further the communica-

tions path to third element **133**, but first element **131** would select the actual connection used from among second and third connections, **142** and **143**, respectively. First element **131** may signal CCP **120** over third link **193** of its selection so that CCP **120** may signal third element **133** of the connection over fifth link **195**. In this embodiment, CCP **120** would specify the network elements to the elements, which in turn, would select the connections between those network elements.

There are situations in which the selection of a network element and the selection of a connection signify the same thing. On FIG. **1** for example, instructing first element **131** to use first connection **141** is synonymous with an instruction to connect to second element **132**. This is because the connection inevitably connects to the element. The selection of a connection may effectively select a network element, and the selection of a network element may effectively select a connection (or a group of specific connections) to that network element.

One skilled in the art will recognize that the selection process can be distributed among the CCP and the elements. The CCP might select all the network elements, a portion of the network elements, or none of the network elements leaving the switches to select the remainder. The CCP might select all of the connections, a portion of the connections, or none of the connections, again leaving the elements to select the remainder. The CCP may select combinations of the above options, but the CCP will always select at least one network characteristic.

In another embodiment, first point **170** may want to access a other network elements such as servers, platforms or operator centers. For example, such elements could be located at either fifth or sixth network elements **135**, and **136** respectively. CCP **120** will receive signaling from first point **170** over first link **191** indicating this request, and first point **170** will typically seize first point connection **171** to first element **131**. Again CCP **120** will select network elements. If sixth element **136** is selected, CCP **120** could select a communications path from first element **131** through either second element **132** to fourth element **134** and then to third element **133**, or through a direct connection from first element **131** to third element **133**. If CCP **120** selects the latter, it would signal first element **131** to further the communications path to third element **133**, and it would signal third element **133** to further the communications path to sixth element **136**. As discussed in the above embodiments, CCP **120** may also select the connections, or the elements may be left with that task.

As is known in the art, in-band signaling is typically used in many user to network connections, such as the local loop. This is because only one connection or link is typically provided to the user premises and thus, the signaling must be placed on the actual communications path. The initial network switch typically removes the signaling from the communications path and transfers it to an out-of-band signaling system. The current invention is fully operational in this context. Although the switch may receive the signaling initially, it will only route the signaling to the CCP for processing. Even if in-band signaling is used within the network, the switches could remove signaling from the communications path and route it to the CCP for processing in accord with the present invention.

Thus, preferably the CCP processes signaling before it is applied or processed by the switch such as to select connections or generate queries. Preferably, no or minimal changes are made to the signaling prior to the signaling being received by the CCP so that the CCP receives the signaling in the same format as a switch would receive the signaling. The CCP may also process the signaling in that format. The switches make their selections based on the CCP selections, thus the switch selections clearly occur after the CCP has processed the signaling. As such, the switch may route signaling to the CCP, but the switch does not apply the signaling. Some examples of a switch applying the signaling would be selecting network elements or generating queries for remote devices.

In one of the above embodiments, the switches did not select the network elements and connections, initiate the signaling, or otherwise control the communication. The switches only followed the instructions of the CCP and actually made the connections that furthered the communications path. In one embodiment, the switches were allowed to select the actual connections used, but even these selections were based on CCP selections.

As illustrated above, the CCP allows a telecommunications network to separate communication control from the communications path. In prior systems, the switches would select the network elements and the connections, as well as, actually providing a part of the actual connection. As a result, prior systems are restricted to the communication control capabilities provided by the switches. Prior systems have used remote devices, such as an SCP, to support switch control, but the remote device only answered queries in response to the switches processing of the signal. These remote devices do not process the signaling before the switch had already applied the signaling. By using the CCP, telecommunications systems can control communications independently of the capability of the switches to accomplish both tasks.

FIG. **2** shows a block diagram of another embodiment of the present invention. CCP **250** and network **210** are shown. CCP **250** is a communications control processor. CCP **250** could be integrated into network **210**. but need not be and is shown separately for clarity. Network **210** could be any type of telecommunications network that operates using network elements, signaling, and connections. Examples would be LECs, IXCs, LANs, MANs, WANs. and Cellular Networks, but there are others. Additionally, network **210** could be narrowband, broadband, packet-based, or a hybrid. Network **210** is capable of providing communications paths between points both inside and outside of network **210**. CCP **250** and network **210** are linked by link **214** and are able to signal each other in order to establish these paths.

Additionally, user **220** and user **230** are shown and are also capable of signaling. Examples of users **220** and **230** might be telephones, computers, or even switches in another telecommunications network. Users **220** and **230** are connected to network **210** by connections **222** and **232** respectively. Users **220** and **230** are linked to CCP **250** by links **224** and **234** respectively. Signaling may be transmitted over links **224** and **234**. If in-band signaling is employed on connections **222** and **232**, network **210** would separate at least a portion of the signaling out-of-band and transmit it to CCP **250** over link **214**.

Also shown are various network elements. As with CCP **250**, these elements could also be integrated into network **210**, but are shown separately for clarity. These network elements are: networks **260**, operator centers **262**, enhanced platforms **264**, video servers **266**, voice servers **268**, and adjunct processors **270**. This is not an exclusive list. Those skilled in the art will recognize these network elements and their functions, as well as the many other types of telecom-

munications devices, such as billing servers, that are applicable in this situation.

Each network element is connected to network **210** by connection **212**. Connection **212** represents several actual connections between the network elements (**260–270**) and different elements in network **210**. One bus-type connection is shown for purposes of clarity, but those skilled in the art are familiar with many actual types of connections to use. Additionally link **256** is shown from CCP **250** to the network elements (**260–270**). Link **256** is similarly represented as a bus-type link for clarity, and multiple links are actually used, although some network elements may not even require links. Link **214** has been simplified for clarity in the same fashion.

In one embodiment, user **220** may desire to establish a communications path to user **230**. CCP **250** would make the appropriate selections and signal the network elements in network **210** as discussed with regard to the embodiments of FIG. **1**. As a result, a communications path would be established from user **220** to user **230** through network **210** and connections **222** and **232**.

In another embodiment, user **220** may desire to access one of the various network elements (**260–270**). User **220** will typically seize connection **222** to network **210** and generate signaling. Both in-band signaling on connection **222** and out-of-band signaling on link **224** would be directed to CCP **250**. By processing the signaling, CCP **250** can select any of the network elements (**260–270**) and control the communications through network **210** and connection **212** to the network elements (**260–270**).

For example, should user **220** desire to connect to a video server and another network, user **220** would signal the request. The signaling would be directed to CCP **250** over link **224**, or over connection **222** and link **214** as discussed above. CCP **250** would process the signaling and make the appropriate selections. CCP **250** would signal network **210** and video servers **266** of its selections. As a result, a communications path would be set-up from user **220** to video servers **266**.

Additionally, CCP **250** would control communications to the other network which is represented by networks **260**. Networks **260** could be any other form of telecommunications network—either public or private. CCP **250** would make the appropriate selections to further the communications path over connection **212** and network **210** to networks **260**. Upon signaling from CCP **250**, the connections comprising the communications path would be made. Networks **260** would also be signalled by CCP **250** over link **256**. As such a communication path is set up from user **230** to video servers **266** and on to networks **260**.

There may also be several devices represented by particular network element shown on FIG. **2**. CCP **250** could also select the particular device to access. For example, take the situation in which voice servers **268** represents **20** individual voice server devices split among three different locations. On each call, CCP **250** could select the actual voice server device which should be used on that call and control the communications through network **210** and connection **212** to the selected device. Alternatively, CCP **250** may only be required to select group of devices, for instance at a particular location, instead of the actual device.

As is known, large telecommunication networks are comprised of numerous network elements. connections, and links. The present invention is suitable for use in this context. FIG. **3** shows a version of the present invention in the context of a large network. Typically, this network would be comprised of several broadband switches, narrowband switches, muxes, signal transfer points (STPs), Service Control Points (SCPs), operator centers, video servers, voice servers, adjunct processors, enhanced services platforms, connections, and links. For purposes of clarity, only a few of these possibilities are shown on FIG. **3**. For the same reason, connections and links are not numbered.

FIG. **3** shows Telecommunications Network **310** which is comprised of STP **340**, STP **345**, CCP **350**, SCP **355**, broadband switches **360**, **362**, **364**, and **366**, interworking units **361** and **365**, narrowband switches **370** and **375**, and muxes **380**, **382**, **384**, and **386**. Aside from CCP **350**, these elements of a large network are familiar to one skilled in the art and examples of the of these network elements are as follows: STP—DSC Communications Megahub; SCP—Tandem CLX; broadband switch—Fore Systems ASX-100; narrowband switch—Northern Telecom DMS-250; and mux—Digital Link PremisWay with CBR module.

In at least one embodiment, the broadband switches are equipped with signaling interworking units. These units translate SS7 messages into B-ISDN messages. In that event, the CCP could transmit SS7 to the broadband switches which could convert the signals properly. Interworking is discussed in ITU-TS Recommendation Q.2660, "B-ISDN, B-ISUP to N-ISUP Interworking".

When user information passes from a broadband network to a narrowband network, it typically must pass through a mux. Muxes can convert transmitted information back and forth between narrowband and broadband formats. In at least one embodiment, each broadband connection on one side of a mux corresponds to a narrowband connection on the other side of the mux. In this way, the CCP can track connections through the mux. If the communication path is on a given narrowband connection entering the mux, it will exit the mux on its corresponding broadband connection. This correspondence allows the CCP to identify connections on each side of the mux based on the entry connection. Muxes are typically placed at any interface between narrowband and broadband connections.

As long as the connections correspond through the mux, the CCP can track the communication path properly. Alternatively, the connections may not correspond. In that case, signaling links between the muxes and the CCP would be required for the devices to communicate and allow the CCP to track the communication path.

Additionally, Telecommunications Network **310** includes the connections and links which are not numbered. These connections and links are familiar to those skilled in the art. Some examples of possible connections are switched digital lines, satellite links, microwave links, cellular links, and dedicated digital lines, but there are others. The signaling links are typically data links, such as 56 kilobit lines. The signaling may employ SS7, Broadband, C6, C7, CCIS, Q.933, Q.931, T1.607, Q.2931, B-ISUP or other forms of signaling technology. The present invention is fully operational with the many variations which are well known in the art. Additionally, it is also known that a direct link between two devices can be used instead of an STP for signal routing.

Outside of Telecommunications Network **310** are first point **320**, second point **330**, LEC switch **325**, LEC switch **335**, LEC STP **328**, and LEC STP **338**. These devices are shown along with their links and connections. First point **320** is connected to LEC switch **325**. LEC switch **325** is linked to LEC STP **328** which routes signaling from LEC switch **325**. LEC switch **325** is also connected to mux **380** of Telecommunications Network **310**. LEC STP **228** is linked to STP **340** of Telecommunications Network **310**.

STP **340** is linked to STP **345**. The other links are as follows. STPs **340** and **345** are linked to CCP **350**. CCP **350** is linked to interworking units **361** and **365** of broadband switches **360** and **364** respectively. CCP **350** is linked to broadband switches **362** and **366**, and narrowband switch **375**. STP **345** is linked to narrowband switch **370** and SCP **355**. STP **345** is also linked to LEC STP **338** which is linked to LEC switch **335**.

Mux **380** is connected to broadband switch **360**. Broadband switch **360** is connected to broadband switches **362** and **364**. Broadband switch **362** is connected to mux **384** which is connected to narrowband switch **375**. Broadband switch **364** is connected to mux **382** which is connected to narrowband switch **370**. Broadband switches **362** and **364** are both connected to broadband switch **366**. Broadband switch **366** is connected to mux **386** which is connected to LEC switch **335**. LEC switch **335** is connected to second point **330**.

When a call is placed from first point **320** that requires the use of Telecommunications Network **310**, LEC switch **325** will typically seize a connection to Telecommunications Network **310** and generate a signal containing call information. At present, this signal is in SS7 format and the seized connection is a DS**0** port. The signal is transmitted to LEC STP **328** which transfers it on to STP **340**. LEC switch **325** also extends the communication path over the seized connection. These LEC components and the process of establishing communication paths between a point, a LEC, and an IXC are familiar to those skilled in the art.

Telecommunications Network **310** accepts the communication path on the narrowband side of mux **380**. The present invention can also accept broadband calls that do not require a mux, but typically, calls from a LEC will be narrowband. Mux **380** converts the call to broadband and places it on the broadband connection that corresponds to the seized connection. The communication path extends to broadband switch **360** through mux **380**.

STP **340** transfers the signal from LEC STP **328** to STP **345** which, in turn, routes the signal to CCP **350**. Also, CCP **350** accepts status messages from the broadband and narrowband switches over standard communications lines, and may query SCP **355** for information. Any suitable database or processor could be used to support CCP **350** queries. CCP **350** uses this information and its own programmed instructions to make communication control selections. For calls that require narrowband switch treatment, CCP **350** will select the narrowband switch.

Preferably, CCP **350** can select any narrowband switch in Telecommunications Network **310**. For example, it may extend the communication path through the broadband network to a narrowband switch across the network for processing, or it may extend the communication path to a narrowband switch connected to the broadband switch that originally accepts the communication path. Additionally, no narrowband switch may be required at all. For clarity, all of the switches representing these possibilities are not shown on FIG. **3**.

CCP **350** will select at least one network characteristic in response to the signaling. Typically, this will be the network elements or connections that will make the communication path. As discussed with regard to the above embodiments, CCP **350** may select only the network elements and allow the switches to select the connections, or the selections can be distributed among the two. For example, CCP **350** may only select some of the network elements and connections and allow the switches to select some of the network elements and connections. CCP **350** might only select the narrowband switches and allow the broadband switches to select the broadband switches that will make the communication path. CCP **350** can also select other network characteristics, such as applications and control instructions.

In one embodiment, CCP **350** will select the narrowband switches to process particular calls and the DS**0** ports on those switches which will accept these calls. The broadband switches will select the broadband switches and the broadband connections to the DS**0** port. Restricted to the possibilities depicted on FIG. **3**, CCP **350** may select either narrowband switch **370** or narrowband switch **375** to process the call. Assuming CCP **350** selects narrowband switch **370**, it would also select a DS**0** port on narrowband switch **370** to accept the connection. CCP **350** would then signal broadband switch **360** through interworking unit **361** to further the communications path to the selected DS**0** port on narrowband switch **370**.

Of the possible routes, broadband switch **360** would be left to select the other broadband switches and connections to use. Assuming the route directly to broadband switch **364** is selected, broadband switch **360** would further the communications path to that switch. Broadband switch **360** would also signal broadband switch **364** of the communication path. Broadband switch **364** would further the communication path to through mux **382** to access the specified DS**0** port on narrowband switch **370**. This is accomplished by corresponding the connections through the mux as discussed above.

CCP **350** will signal narrowband switch **370** of the incoming communication path. This signal is routed by STP **345**. Narrowband switch **370** will process the call on the specified DS**0** port. Typically, this would include billing and routing the call. Narrowband switch **370** may also query SCP **355** to aid in application of services to the call. For example, narrowband switch **370** may retrieve an "800" translation from SCP **355**. As a result of the processing, narrowband switch **370** will switch the call and generate a new signal which may include routing information. The signal is sent to CCP **350** through STP **345**. The communication path is furthered on a new connection back to broadband switch **364** through mux **382**. CCP **350** may use the information in the signal, SCP information, network element information, operational instructions, and/or its own routing logic to make new selections for the call. The network element information and operational instructions could be signalled to CCP **350** or delivered over standard data lines.

In one embodiment, the selection of a network characteristic will include the selection of a network code. Network codes are the logical addresses of network elements. One such code is a destination code that facilitates egress from Telecommunications System **310**. The destination code typically represents a network element that is connected to a LEC switch. Once a destination is selected, CCP **350** will signal broadband switch **364** of its selections and the communication path will be furthered through the broadband network accordingly. In the current example this could be through broadband switch **366** and mux **386**. The communication path would be furthered to the specified port on LEC switch **335**. Typically, this involves the seizure of a connection on the LEC switch by the IXC.

In one embodiment, whenever broadband switch **366** extends a communication path to mux **386**, it is programmed to signal CCP **350** of the broadband connection it has selected. This allows CCP **350** to track the specific DS**0** port on the LEC switch that has been seized. CCP **350** would

signal LEC switch **335** through STP **345** and LEC STP **338** of the incoming call on the seized DS**0** connection. As a result, LEC switch **335** would further the communication path to second point **330**.

It can be seen from the above disclosure that the present invention allows a telecommunications network to employ a broadband network to make call connections. By using muxes to convert calls and a CCP to analyze signaling, this broadband network remains transparent to the networks of other companies. An example of such a transparent interface is between an interexchange carrier (IXC) network and a local exchange carrier (LEC) network. Similarly the network will be transparent if deployed in only a portion of a single company's network infrastructure.

In the above embodiment, the LEC seizes an IXC DS**0** port and signals to an IXC STP. The mux and the CCP convert the call and analyze the signal appropriately. No changes in other existing carrier systems, such as LEC systems, are required.

Additionally the narrowband switch receives the call and signal in its own format and switches the call. Although the switch may "think" the call is routed over a trunk to another narrowband switch, the call actually goes right back to the mux and broadband switch that sent the call. The narrowband switch is used to apply features to the call, i.e. billing, routing, etc. The broadband network is used to make the substantial portion of the call connection. The CCP may use narrowband switch call processing information to make selections.

The CCP performs many functions. In one embodiment, it accepts signaling from a first point or LEC and provides appropriate signals in accord with the communication control selections it has made. These selections are network characteristics. The CCP may select network elements such as switches, servers, or network codes. The CCP may select connections, such as DS**0** circuits and ports. The CCP may select particular telecommunications applications to be applied to the communications path. The CCP may select particular control instructions for particular devices. The CCP may also receive information from entities such as SCPs, operational control, or switches to aid in its selections.

The CCP is a processing system, and as such, those skilled in the art are aware that such systems can be housed in a single device or distributed among several devices. Additionally, multiple devices with overlapping capabilities might be desired for purposes of redundancy. The present invention encompasses these variations. One such operational system would be multiple pairs of CCPs located regionally within a telecommunications system. Each machine would be equally capable of communication control. One example of a CCP device would be a Tandem CLX machine configured in accord with this disclosure of the present invention.

A signaling point handles the signaling for a switch. Switches which are used to route calls typically have a signaling point which is directly coupled to a processor in the switch. This processor controls a switching matrix in the switch in response to the signaling processed by the signaling point. Thus, there is typically a one to one correspondence of a signaling point for each switch and matrix.

The CCP is not directly coupled to one switch, one switch processor (CPU), or one switching matrix. In contrast, the CCP has the capability of directing a plurality of switches. Thus, the CCP can direct multiple switch matrixes by signaling multiple signaling points.

It is possible to house the CCP within other telecommunication devices, even switches. Although the CCP can be primarily distinguished from a switch CPU based on physical location, this does not have to be the case. A switch CPU receives information from a signaling point and controls the matrix of a single switch. Some switches distribute the matrix among different physical locations, but the CPU controls each matrix based on information received from a single signaling point. This information is not signaling.

In contrast, the CCP receives signaling and has the ability to signal other network elements. It can communicate with multiple signaling points. These signaling points provide information to the switch CPUs which control the switch matrixes. By signaling multiple signaling points, the CCP is able to direct the matrixes of multiple switches based on the signaling and other information the CCP obtains. A CCP is not associated with a single switch matrix. A CCP does not require communication path connections in order to operate.

The main capabilities of one version of a CCP are shown on FIG. **4**. CCP **450** comprises interface **460**, translator **470** operably connected to interface **460**, processor **480** operably connected to translator **470**, and memory **490** operably connected to processor **480**.

CCP **450** functions to physically connect incoming links from other devices such as STPs, switches, SCPs, and operational control systems. Interface **460** is functional to accept the signals off of these links and transfer the signals to translator **470**. Interface **460** is also be able to transfer signaling from translator **470** to the links for transmission.

Translator **470** accepts the signaling from interface **460** and identifies the information in the signaling. Often, this will be done by identifying a known field within a given signaling message. For example, translator **470** might identify the Origination Point Code (OPC), Destination Point Code (DPC), and Circuit Identification Code (CIC) in an SS7 message. Additionally, translator **470** must be able to formulate outgoing signaling and transmit it to interface **460** for transmission. For example, translator **470** might replace the OPC, DPC, and CIC in a given SS7 message and transfer the modified SS7 message to interface **460** for transmission. Translator **510** must be equipped to manage the signaling formats it will encounter. Examples are SS7 and C7.

Processor **480** accepts the signaling information from translator **470** and makes the selections that accomplish communication control. This includes the selection of the network elements and/or connections that make the communications path. Typically, selections are made through table look-ups and SCP queries. Tables are entered and queries are generated based in part on the information identified by translator **470**. The table look-ups and SCP information retrieval yield new signaling information. The new information is transferred to translator **470** for formulation into appropriate signals for transmission. Algorithm solution could also be used to make selections. Processor **480** also handles various status messages and alarms from the switches and other network elements. Operational control can also be accepted. This information can be used to modify the look-up tables or selection algorithms. Memory **490** is used by processor **480** to store programming, information, and tables.

FIG. **5** shows a flow diagram for the CCP for a version of the present invention. The sequence begins with the CCP receiving different types of information. Box **500** depicts the CCP accepting a signal from a first point. This signal could be in any format, such as SS7 or broadband signaling. The signal may have passed through STPs from a LEC over a signaling link, or it may also be a signal directly provided by an individual user of a network. The signal contains infor-

mation about the requested communication path. An example of such information is the message type which indicates the purpose of the message. Another example of such information is set-up information such as transit network service value, bearer capability, nature of address, calling party category, address presentation restriction status, carrier selection value, charge number, and originating line information, and service code value. Other information might be a network indicator or a service indicator. Those skilled in the art are familiar with these types of information.

Other types of information might also be accessed by the CCP. The network elements, such as switches, may provide the CCP with information as shown in box **505**. This information allows the CCP to select network elements and connections based on network conditions. Examples of possible types of such information could be management messages, loading, error conditions, alarms, or idle circuits. The CCP might also provide the network elements with information.

Box **510** shows that operational control might be provided. Operational control allows system personnel to program the CCP. An example of such control might be to implement a management decision to retire a particular network element. Operational control would allow the removal that element from the selection process.

The CCP processes the information is has received in box **515**. Processing also entails the use of programmed instructions in the CCP, and might even include the use of information retrieved from a remote database, such as an SCP. The selections are then made as shown in box **520**. These selections specify network characteristics, such as network elements and/or connections. As stated above, The CCP may only select a portion of the network characteristics and allow the points or the switches to select the remainder. It should be pointed out that the information used in processing is not limited to that which is listed, and those skilled in the art will recognize other useful information which may be sent to the CCP.

Once network characteristics are selected, the CCP will signal the points and the applicable network elements of the selections. In box **525**, signals are formulated instructing the network elements of the network characteristics selected. The signals are transmitted to the appropriate network elements in box **535** which will typically result in a communication path through the network elements and connections. Other activity, such as applications and control procedures might be implemented as well. Additionally, in boxes **530** and **540**, signals are formulated and sent to the points. Typically the new signals generated by the CCP are sent to network elements or multiple signaling points. These new signals could be the same, however different signaling is typically sent to the different network elements which may used as part of a communication path.

FIG. **5** represents the sequence that the CCP performs in one embodiment to control communications and establish a communication path from a first point to a second point through network elements and connections. FIGS. **6** and **7** represent a similar sequence, and they are in the context of an Interexchange Carrier (IXC) similar to that depicted in FIG. **3**. The IXC accepts DS**0** connections and SS7 signaling from a LEC and employs a broadband system to make the substantial portion of the communication path.

FIG. **6** depicts the flow of the CCP in a version of the present invention when a communication path is established from the LEC to a narrowband switch in the IXC. Box **600** shows that an SS7 message is accepted from the LEC which contains a Message Transfer Part (MTP) and an Integrated Service User Part (ISUP). As those skilled in the art are aware, the MTP contains the Originating Point Code (OPC) and the Destination Point Code (DPC). These point codes define specific signaling points in the network and are typically associated with a switch. As such, the OPC and DPC define a portion of the desired communication path.

When the communication path is extended into the IXC network, the OPC designates the LEC switch that connected to the IXC (**#325** on FIG. **3**). Previously, the DPC has designated the narrowband switch that the LEC would connect to for calls into the IXC. In this embodiment of the present invention, the DPC may designate a particular narrowband switch from the LEC's perspective, but the CCP actually selects the actual narrowband switch used. A mux or a broadband switch accepts the connection from the LEC, not a narrowband switch.

The ISUP contains the Circuit Identification Code (CIC) which designates the DS**0** port that the LEC has seized. Previously, this DS**0** Port was on a narrowband switch, but in this embodiment of the present invention, the DS**0** port is actually on a mux.

Box **605** shows that the CCP may receive status information from the narrowband switches. These messages include Operational Measurements (OM) and CPU Occupancy information. OM includes trunk usage status of the switches which tells the CCP which DS**0** ports are available on the narrowband switches. CPU Occupancy tells the CCP of the specific switching load of each narrowband switch. Box **610** shows that the CCP may also accept status information from the broadband switches indicating which connections are idle. This information allows the CCP to specify and balance routing through the broadband switches if desired. As discussed in relation to some of the other embodiments, the broadband switches may be left with that selection.

The CCP processes the information it has received in box **615**. Those skilled in the art are aware of other information which would be useful in this context. As a result of the processing, a narrowband switch and a DS**0** port on that switch are typically selected as shown in box **620**. The selected narrowband switch may be close to the LEC or across the broadband network. The CCP determines which narrowband switch will process the call. This makes the narrowband switches virtually interchangeable.

Box **625** shows that a signal indicating these selections is generated and sent to the appropriate broadband switches in box **635**. As discussed, the broadband switches may employ interworking units to handle signaling. Typically, the broadband switches will use internal tables to select broadband connections based on information in the signal from the CCP. Such information might identify the existing extent of the communication path and specify the narrowband switch and the DS**0** port on that switch to which the communication path should be extended. The tables would be entered with this information and yield a particular broadband connection to use. Broadband switches further along the communications path could also receive similar signals from the CCP and use similar tables. Alternatively, the broadband switches further along the communications path might only need to enter an internal table using the incoming broadband connection and yield a new broadband connection on which to extend the communications path.

Those skilled in the art are familiar with broadband systems which can accomplish this. Broadband signaling is

discussed in the following ITU-TS Recommendations: Q.2762 "B-ISDN, B-ISDN User Part—General Functions of Messages"; Q.2763 "B-ISDN, B-ISDN User Part—Formats and Codes"; Q.2764 "B-ISDN, B-ISDN User Part—Basic Call Procedures"; Q.2730 "B-ISDN, B-ISDN User Part—Supplementary Services"; Q.2750 "B-ISDN, B-ISDN User Part to DSS2 Interworking Procedures"; and Q.2610 "Usage of Cause and Location in B-ISDN User Part and DSS2".

In at least one embodiment, the broadband switches are equipped with signaling interworking units. These units translate SS7 messages into B-ISDN messages. In that event, the CCP could transmit SS7 to the broadband switches which could convert the signals properly. Interworking is discussed in ITU-TS Recommendation Q.2660, "B-ISDN, B-ISUP to N-ISUP Interworking".

In one embodiment, the broadband switches may select the actual virtual connection that corresponds through a mux to a DS**0** port. This DS**0** port could be on a narrowband switch or a on a point, such as a LEC switch. In this case, the CCP would not need to select a DS**0** port since the broadband switch was in effect doing so. The internal tables of the broadband switches would be programmed to trigger when the particular broadband switch was connecting to particular broadband connections. These connections might be to a DS**0** port on a narrowband switch or any specified point. Upon the trigger, the broadband switch would signal the CCP of the broadband connection it has used. The CCP would incorporate this information into the signal it sends to the narrowband switch or specified point. It is preferred that the CCP select the DS**0** port on the selected narrowband switches, and that the broadband switches be allowed to select the broadband connection out of the network (through a mux) and signal the CCP of its selection.

The SS7 message from the LEC informed the CCP which DS**0** port had been seized (the CIC), on which IXC device (DPC), and by which LEC switch (the OPC). By tracking the DS**0** Port through the mux (#**380** on FIG. **3**), the CCP knows which connection the communication path will use to get to the broadband switch (#**360** on FIG. **3**). The CCP provides the broadband network with the proper signaling to extend the communication path from this switch to the selected narrowband switch as shown in box **635**.

Box **630** shows that the CCP formulates an SS7 message based on the selections relating to the narrowband switch. SS7 message formulation methods, such as drop and insert, are known in the art. A new DPC is inserted that will designate the narrowband switch selected by the CCP. A new CIC is inserted that will designate the DS**0** port on that switch as selected by the CCP. The SS7 message is sent to the narrowband switch in box **640**.

As such. the communication path is extended from the LEC through the broadband network to the narrowband switch, and the narrowband switch is notified of the incoming communication path. Another portion of the SS7 message contains call information including ANI and DNIS. This information was supplied by the LEC and is in the SS7 message sent to the narrowband switch.

The narrowband switch uses this information along with its own programming to switch the call. This switching may include various switching programs and remote databases. The narrowband switch will select a new DPC based on this processing. It will switch the call to a new DS**0** port. Previously, this port was connected to a trunk connected to the next narrowband switch in the call routing scenario. However, in the present invention, the DS**0** port is connected through a mux to broadband switch. The narrowband switch will place the new DPC in an SS7 message. Along with the new DPC, a new CIC identifying the new DS**0** circuit, and a new OPC designating the narrowband switch itself is placed in the SS7 message and sent to the CCP.

FIG. **7** shows the flow of the CCP when extending a communication path from the selected narrowband switch to a point outside of the IXC in one embodiment of the present invention. The SS7 message generated by the narrowband switch after processing the call is received by the CCP in box **700**. In it, the CIC designates the DS**0** port the communications path extends from on the narrowband switch. Because this port is connected to a mux with corresponding connections, the CCP can determine which connection the communication path uses to extend back to the broadband switch.

The CCP may also receive status information from the broadband switches as shown in box **705**. This information allows the CCP to select broadband connections if desired. As discussed, the broadband switches may make these selections. Typically, the broadband switches will use internal tables to select broadband connections based on information in the signal from the CCP. Such information might specify destination code. The destination code might correspond to a terminating switch or a LEC switch to which the communication path should be extended.

As shown in box **710**, the CCP applies processing and selects the appropriate destination for the broadband network to extend the communication path to as shown in box **715**. The CCP may use the new DPC provided by the narrowband switch to identify the destination for the broadband communication path.

In box **720**, signals are generated reflecting this selection and sent to the appropriate broadband switches in box **725**. As discussed, the broadband switch may trigger and signal the CCP when it uses particular connections. This would occur for a connection through a mux to a LEC switch. This signal is accepted by the CCP in box **730** and is used to identify the DS**0** port. An SS7 message is formulated in box **735** and in it the CIC will identify this DS**0** connection on the LEC switch (#**335** on FIG. **3**). Alternatively, this DS**0** port may have been selected by the CCP and signalled to the broadband switch. The LEC is signalled in box **740**.

From FIGS. **6** and **7**, a sequence is shown that demonstrates the procedures that the CCP can follow to accept signaling from the LEC and make selections that control communications through the IXC network. The CCP must produce signals to implement its selections and transmit them to the applicable network elements. The CCP is able to use the routing, billing, and service features of a narrowband switch. but is still is able to employ a broadband network to make a substantial part of the communications path.

FIG. **8** is a flow diagram of CCP signal processing in one embodiment of the invention. Box **800** shows that an SS7 signal has been accepted by the CCP. Box **805** shows that the CCP determines the message type. If the message is not a call message, it is routed or used to update the CCP memory if appropriate as shown in box **810**. Non-call messages are familiar to those skilled in the art with examples being filler or management messages. If the SS7 message is a call message, it is examined to determine if it is an initial address message (IAM) in box **815**. Call messages and IAMs are familiar to those skilled in the art. If it is an IAM, the information provided by automatic number identification (ANI) is used to validate the call in box **820**. ANI validation is accomplished with a table look-up and is well known. If invalid, the communication path is terminated as shown in box **825**.

Once an IAM with a valid ANI is determined, a table is entered which yields an OPC—DPC—CIC combination as shown in box **830**. One skilled in the art will recognize that such a table can take many forms. One example is to set up a table with every combination of OPC—DPC—CIC on one side. The table is entered using the OPC—DPC—CIC of the incoming IAM message. After entry through these fields is accomplished, the table yields a new OPC—DPC—CIC which can be formulated into the SS7 message and sent to the switching network as shown in box **835**. The switching network is capable of using this information to make connections.

Once the IAM signal has been processed, subsequent SS7 messaging can be processed by a separate CIC look-up table entered using the CIC as shown in box **840**. Subsequent messages, such as address complete, answer, release, and release complete can be processed by entering the CIC table using the CIC in these non-IAM signals. For signals directed to the first point, the table yields the original OPC which is used as the DPC. Additionally, subsequent messages from the first point enter the CIC table using their CIC, and the table yields the DPC previously selected by the CCP for the IAM processing. The CIC table is constantly updated to reflect current processing as shown in box **845**. In this way, the CCP is able to efficiently process non-IAMs because theses signals only need to reflect the results of previous IAM selections.

There can be exceptions to the use of the CIC table for non-IAM call messages. One example would be if a new connection is allowed after release. In that case, the IAM procedures would be followed.

Those skilled in the art will recognize the numerous factors that can be used to design and load the tables. Different OPC—DPC—CIC combinations can be yielded by the tables based on many factors. Some of these factors are: called number, time of day, CPU occupancy, switch status, trunk status, automatic call distribution, operational control, error conditions, network alarms, user requests, and network element status.

For example, if a certain switch must be taken out of service, it is merely replaced in the table with suitable substitutes. The switch is then effectively taken out of service because it is no longer selected. If the CPU loading of a certain switch reaches a threshold, its presence in the tables can be diminished and distributed to other switches.

In another example, if it is busy hour in region A, the tables may yield network elements in region B to process the call. This can be accomplished by adding an area code or a dialed number entry, and time of day entry in the table. For calls placed from an OPC in region A to an area code or dialed number in region B, a narrowband switch in region B could be selected. As such, the DPC yielded by the table during this time frame should reflect a region B narrowband switch. Also, for calls placed from an OPC in region B to an area code or dialed number in region A, the tables should provide the DPC of a region B narrowband switch.

In a preferred embodiment, IAM messages would cause the CCP to query an SCP, data element, or database for support. The SCP would answer the query by using tables as discussed above. The answers would be sent to the CCP and used to formulate signaling. Subsequent messages would be then handled by the CCP using the CIC table. An example of such support would be for the CCP to query the SCP in response to receiving an IAM message. The query may include the OPC, CIC, DPC, and the area code, or dialed number. The SCP could use this information to select network characteristics and avoid busy regions as described in the above busy region example. For example, the SCP would maintain tables for OPC—dialed area code—time of day combinations that would yield a new DPC and CIC. This assumes that busy hour in a region corresponds to time of day, but other factors and yields could also be involved.

In one embodiment, the dialed number or area code could be used to select the new DPC, and time stamps could be placed in the signaling. This might entail tables with OPC—dialed area code entries that yield a new DPC and CIC. In this case, narrowband switches may not even be needed since billing can be applied using the time stamps. The CCP could then route the call directly using only the broadband network. This is especially relevant for POTS calls in which only an area code entry would need to be added to the tables.

As discussed above, often a connection will consist of two separate connection procedures. One connection procedure will be from the origination to a selected network element. The other connection procedure will be from the selected network element to the destination. Also it has been disclosed that the CCP could actually be discreet machines located regionally. In these cases, the CCP device processing the first connection procedure could be located in the origination region, and the CCP device that processes the second connection procedure could be located in the region of the selected network element.

The present invention offers the advantage of separating at least a portion of the communication control from the communication path. By examining and translating signaling independently of the communication path, multiple switches and network elements can be connected in the optimum way. Communications paths are no longer limited to only the connections the switches can control. Networks do not have to wait for standardization among signaling and interface protocols.

The present invention allows for the selection of network characteristics, such as network elements and connections, before switches process or apply the signaling. The switches are not required to have a capability either to make selections or to signal each other. The switches only make connections as directed by the CCP which signals in each switches own signaling format. Various criteria can be used for the selections in the CCP, such as time of day, load balancing, or invalid ANI. As such, the present invention allows for a smooth transition from narrowband to broadband networks. It also allows for the selection of network elements, such as servers and enhanced services platforms.

The present invention represents a fundamental and powerful departure from previous telecommunications technology. By separating the communications path from communication control, the CCP can utilize different networks and network devices intelligently. Previously, telecommunications systems have been dependent on the switches to accomplish communication control. As such, telecommunications systems have had to wait for the switches to develop communication control before new technology could be implemented. Switches have always been required to physically make connections and provide control over which connections are required. Switch capabilities have not been able to keep up with all of the network possibilities available. The result is a limited system.

Switches have been given support in this dual task. SCPs, STPs, and adjunct processors provide support for communication control. However, these devices only support the switches communication control, and the switch remains essential to communication control. This dependence has created a bottleneck given the available network possibilities.

One advantage of the present invention is that it allows narrowband switches be used interchangeably in a narrowband/broadband hybrid network. Any narrowband switch may be taken out of service without re-routing traffic and changing routing logic in each switch. The CCP is simply programmed not to select the given narrowband switch for call processing. The CCP will route calls over the broadband network to another narrowband switch. This flexibility also allows the telecommunications network to easily transfer narrowband switch loads.

An important advantage of this system is that both the advantages of broadband and narrowband systems are utilized. The transmission capabilities of a broadband network are coupled with the narrowband network's ability to apply features. For example, the CCP can use the broadband network to substantially make the call connection from origination to destination. The CCP diverts the traffic to the narrowband network for processing. The narrowband network can apply features, such as billing and routing. Once processed, the traffic is directed back to the broadband network for completion of the connection. The CCP can then use the routing information generated by the narrowband system to route the traffic through the broadband system to the destination. As a result, the telecommunications system does not have to develop a billing or "800" routing feature for its broadband network. This can be accomplished because the CCP allows both networks to work together intelligently.

Another advantage of the present invention is the elimination of a substantial percentage of the DS**0** ports required on the existing narrowband switches. In the current architectures, narrowband switches are interconnected to each other. A substantial percentage of the switch ports are taken up by these connections. By eliminating the need for the switches to connect to each other, these ports can be eliminated. Each narrowband switch is only connected to the broadband system. This architecture requires fewer ports per switch. By load balancing with the CCP, the number of ports required on busy switches can be reduced. The architecture in the present invention does require additional broadband ports, but these can be added at a significant cost saving versus narrowband ports.

Additionally, the narrowband switches no longer signal each other since all signaling is directed to the CCP. This concentration accounts for a reduction in required signaling link ports. This reduction possibly could result in the elimination of STPs.

As mentioned above, an advantage of the present invention is its ability to treat narrowband switches, or groups of narrowband switches, interchangeably. The CCP can pick any narrowband switch to process a particular call. This allows the network to pull narrowband switches out of service without taking extreme measures. In turn, this simplifies the introduction of new services into the network. A switch can be pulled out of service simply by instructing the CCP to stop selecting it. The switch can be reprogrammed and put back into service. Then the next switch can then be updated in the same manner until all of the switches are implementing the new service. Switches can also be easily pulled to test developing applications.

This narrowband switch flexibility also allows the CCP to balance switch loads through the network during peak times, or during mass calling events. This eliminates the need to implement complex and expensive load balancing features in the narrowband network. Instead of programming the several switches to balance among themselves, one command to the CCP can achieve this.

Another advantage is the reduction in call set-up time. Most large networks require that a call pass through more than two narrowband switches arranged in a hierarchical fashion. One large network employs a flat architecture in which all narrowband switches are interconnected, but this still requires that the call pass through two narrowband switches. In the present invention, only one narrowband switch is required for each call. The use of broadband switches to set-up and complete the call represents significant time savings.

What is claimed is:

1. A method for handling a call having a first message and communications, the method comprising:

receiving and processing the first message in a processing system external to narrowband switches to select one of the narrowband switches;

generating a second message in the processing system based on the selected narrowband switch and transmitting the second message from the processing system; and

receiving the second message and the communications in an asynchronous communication system and transferring the communications to the selected narrowband switch in response to the second message.

2. The method of claim **1** further comprising:

generating a third message in the processing system based on the selected narrowband switch and transmitting the third message from the processing system;

receiving and processing the third message in the narrowband switch to select a route and generating and transmitting a fourth message indicating the selected route; and

receiving the communications in the selected narrowband switch and transmitting the communications from the selected narrowband switch based on the selected route.

3. The method of claim **2** further comprising:

receiving and processing the fourth message in the processing system to generate and transmit a fifth message; and

receiving the fifth message and the communications in the asynchronous communication system and transferring the communications based on the selected route in response to the fifth message.

4. The method of claim **1** wherein processing the first message to select the narrowband switch comprises processing a destination point code from the first message.

5. The method of claim **1** wherein processing the first message to select the narrowband switch comprises processing an origination point code from the first message.

6. The method of claim **1** wherein processing the first message to select the narrowband switch comprises processing a circuit identification code from the first message.

7. The method of claim **1** wherein processing the first message to select the narrowband switch comprises processing an area code from the first message.

8. The method of claim **1** wherein processing the first message to select the narrowband switch comprises processing a called number from the first message.

9. The method of claim **1** wherein processing the first message to select the narrowband switch comprises processing a time of day.

10. The method of claim **1** wherein processing the first message to select the narrowband switch comprises processing a load of the narrowband switch.

11. The method of claim **1** wherein processing the first message to select the narrowband switch comprises processing network access to the narrowband switch.

12. The method of claim **1** wherein processing the first message to select the narrowband switch comprises processing a network maintenance condition.

13. The method of claim **1** wherein receiving and processing the first message comprises receiving and processing an initial address message.

14. The method of claim **1** wherein processing the first message to select the narrowband switch comprises accessing a service control point.

15. The method of claim **1** further comprising receiving and processing an answer message and a release message for the call in the processing system.

16. The method of claim **1** further comprising generating an initial address message for the call in the processing system and transferring the initial address from the processing system.

17. The method of claim **1** wherein the asynchronous communication system comprises an asynchronous transfer mode system.

18. A communications system for handling a call having a first message and communications, the communication system comprising:

a processing system external to narrowband switches and configured to receive and process the first message to select one of the narrowband switches and to generate and transmit a second message based on the selected narrowband switch; and

an asynchronous communication system configured to receive the second message and the communications and transfer the communications to the selected narrowband switch in response to the second message.

19. The communication system of claim **18** wherein:

the processing system is configured to generate and transmit a third message based on the selected narrowband switch and further comprising:

the selected narrowband switch configured to receive and process the third message to select a route, generate and transmit a fourth message indicating the selected route, and receive and transmit the communications based on the selected route.

20. The communication system of claim **19** wherein:

the processing system is configured to receive and process the fourth message to generate and transmit a fifth message; and

the asynchronous communication system is configured to receive the fifth message and the communications and transfer the communications based on the selected route in response to the fifth message.

21. The communication system of claim **18** wherein the processing system is configured to process a destination point code from the first message to select the narrowband switch.

22. The communication system of claim **18** wherein the processing system is configured to process an origination point code from the first message to select the narrowband switch.

23. The communication system of claim **18** wherein the processing system is configured to process a circuit identification code from the first message to select the narrowband switch.

24. The communication system of claim **18** wherein the processing system is configured to process an area code from the first message to select the narrowband switch.

25. The communication system of claim **18** wherein the processing system is configured to process a called number from the first message to select the narrowband switch.

26. The communication system of claim **18** wherein the processing system is configured to process a time of day to select the narrowband switch.

27. The communication system of claim **18** wherein the processing system is configured to process a load of the narrowband switch to select the narrowband switch.

28. The communication system of claim **18** wherein the processing system is configured to process network access to the narrowband switch to select the narrowband switch.

29. The communication system of claim **18** wherein the processing system is configured to process a network maintenance condition to select the narrowband switch.

30. The communication system of claim **18** wherein the first message comprises an initial address message.

31. The communication system of claim **18** wherein the processing system is configured to access a service control point to process the first message.

32. The communication system of claim **18** wherein the processing system is configured to receive and process an answer message and a release message for the call.

33. The communication system of claim **18** wherein the processing system is configured to generate and transmit an initial address message for the call.

34. The communication system of claim **18** wherein the asynchronous communication system comprises an asynchronous transfer mode system.

* * * * *

EXHIBIT E

US006473429B1

(12) **United States Patent**
Christie

(10) **Patent No.: US 6,473,429 B1**
(45) **Date of Patent: Oct. 29, 2002**

(54) **BROADBAND TELECOMMUNICATIONS SYSTEM**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/353,401**

(22) Filed: **Jul. 15, 1999**

Related U.S. Application Data

(63) Continuation of application No. 08/525,897, filed on Sep. 8, 1995, now Pat. No. 5,991,301, which is a continuation-in-part of application No. 08/568,551, filed on Dec. 7, 1995, now Pat. No. 5,825,780, which is a continuation of application No. 08/238,605, filed on May 5, 1994, now abandoned.

(51) **Int. Cl.**[7] **H04L 12/56**; H04L 12/28
(52) **U.S. Cl.** **370/395.3**; 370/410; 370/466
(58) **Field of Search** 370/389, 395, 370/396, 397, 398, 399, 400, 410, 384, 385, 395.1, 395.3, 395.71, 466; 379/219, 229, 230

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,453,247 A 6/1984 Suzuki et al.
4,720,850 A 1/1988 Oberlander et al.
4,763,317 A 8/1988 Lehman et al.
4,926,416 A 5/1990 Weik
5,051,983 A 9/1991 Kammerl
5,115,431 A 5/1992 Williams et al.
5,168,492 A 12/1992 Beshai et al.
5,204,857 A 4/1993 Obara
5,233,607 A 8/1993 Barwig et al.
5,274,680 A 12/1993 Sorton et al.
5,327,421 A 7/1994 Hiller et al.

(List continued on next page.)

OTHER PUBLICATIONS

McDysan, David E. and Spohn, Darren L., ATM Theory And Application, 1994, p. 256: 9.3.1; ATM Layer VPI/VCI Level Addressing.

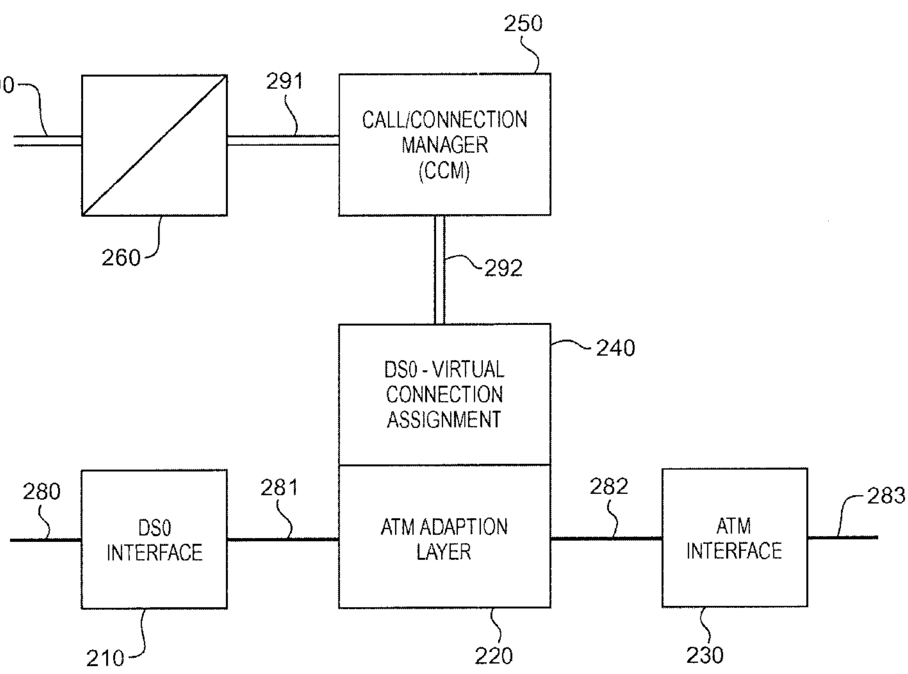
(List continued on next page.)

Primary Examiner—Ajit Patel
(74) *Attorney, Agent, or Firm*—Harley R. Ball; Steven J. Funk; Kevin D. Robb

(57) **ABSTRACT**

The invention is a system for providing virtual connections through an ATM interworking multiplexer on a call-by-call basis. A signaling processor receives signaling for a call and selects the virtual connection for the call. The signaling processor generates new signaling that identifies the selection and transfers the new signaling to the ATM interworking multiplexer that accepted the access connection for the call. The multiplexer converts user information from the access connection into ATM cells for transmission over the virtual connection in accord with the new signaling.

44 Claims, 12 Drawing Sheets



U.S. PATENT DOCUMENTS

5,339,318	A		8/1994	Tanaka et al.	
5,345,445	A		9/1994	Hiller et al.	
5,345,446	A		9/1994	Hiller et al.	
5,365,524	A		11/1994	Hiller et al.	
5,392,402	A		2/1995	Robrock, II	
5,414,701	A		5/1995	Shtayer et al.	
5,420,858	A		5/1995	Marshall et al.	
5,422,882	A		6/1995	Hiller et al.	
5,426,636	A		6/1995	Hiller et al.	
5,428,607	A		6/1995	Hiller et al.	
5,428,609	A		6/1995	Eng et al.	
5,434,852	A		7/1995	La Porta et al.	
5,452,296	A		9/1995	Shimizu	
5,452,297	A		9/1995	Hiller et al.	
5,459,722	A		10/1995	Sherif	
5,473,679	A	*	12/1995	La Porta et al.	379/201
5,479,402	A		12/1995	Hata et al.	
5,483,527	A	*	1/1996	Doshi et al.	370/395
5,497,373	A		3/1996	Hulen et al.	
5,509,010	A		4/1996	LaPorta et al.	
5,513,355	A		4/1996	Doellinger et al.	
5,530,724	A		6/1996	Abrams et al.	
5,550,820	A		8/1996	Baran	
5,570,368	A		10/1996	Murakami et al.	
5,577,039	A		11/1996	Won et al.	
5,623,491	A		4/1997	Skoog	
5,623,493	A		4/1997	Kagemoto	
5,673,262	A		9/1997	Shimizu	
5,684,792	A		11/1997	Ishihara	
5,771,234	A		6/1998	Wu et al.	
5,787,086	A		7/1998	McClure et al.	
5,805,568	A		9/1998	Shinbashi	
5,825,780	A		10/1998	Christie	
5,926,482	A		7/1999	Christie	
5,991,301	A		11/1999	Christie	
6,014,378	A		1/2000	Christie et al.	
6,016,319	A	*	1/2000	Kshirsagar et al.	370/410
6,016,343	A		1/2000	Hogan et al.	
6,023,474	A		2/2000	Gardner	
6,064,648	A	*	5/2000	Hellman et al.	370/230
6,067,299	A		5/2000	DuRee	
6,081,529	A		6/2000	Christie	
6,115,380	A		9/2000	Christie et al.	
6,172,977	B1		1/2001	Christie et al.	
6,201,812	B1		3/2001	Christie	
6,208,660	B1		3/2001	Christie	
6,212,193	B1		4/2001	Christie	

OTHER PUBLICATIONS

"Revised Draft Of Q.2650 (DSS2/B–ISUP Interworking Recommendation)," Study Group 11, Geneva, ITU–Telecommunication Standardization Sector, Nov. 29–Dec. 17, 1993.

"Draft Broadband/Narrowband NNI Interworking Recommendation," Study Group 11, Geneva, ITU—Telecommunication Standardization Sector, Dec. 1993.

Yoshikai, N., et al., "General Arrangements for Interworking Between B–ISDN and 64kbit/s Based ISDN (Draft Recommendation I.580), Study Group 13," ITU–T Telecommunication Standardization Sector, pp. 1–51, (Mar. 7, 1994).

"Interworking B–ISUP and Q.93B for, DDI, MSN, TP and SUB", Study Group, 11, Temporary Document 2/II–131I, ITU–Telecommunication Standardization Sector, Nov. 29–Dec. 17, 1993.

Minoli, Daniel/DVI Communications, Inc./Stevens Institute of Technology and Dobrowski, George/Bell Communications Research (Bellcore), Principles Of Signaling For Cell Relay And Frame Relay© pp. 1–2, 5–6 and 229, 1994.

McKinney, Scott, "ATM for Narrowband Services" 2460 IEEE Communications Magazine, Apr. 1994, New York, US, pp. 64–72.

Kuribayashi, Shin–ichi, "Advanced Signaling Protocol for Broadband ISDN Services" Electronics and Communications in Japan, Part 1, vol. 78 No. 1, 1995, Jan., New York, US, pp. 1–12.

ITU–T Q.1208, General Aspects of the Intelligent Network Application Protocol, ITU–T Recommendation Q.1208.

ITU–Y Q.1218 Addendum 1, Series Q: Switching and Signalling Intelligent Network, Interface Recommendation for Intelligent Network CS–1, Addendum 1: Definition for two new contexts in the SDF data model.

Tanabe, Shirou, et al., "A New Distributed Switching System Architecture for B–ISDN," International Conference on Integrated Broadband Services and Networks, Oct. 15–18, 1990, The Institution of Electrical Engineers, Savoy Place, London.

Palmer, Rob, et al., "Experimental ATM Network Featuring De–Coupled Modular Control," IEEE Region 10 Conference, TENCON, Nov. 1992.

ITU–T Recommendation I–121 (Apr. 1991) Broadband Aspects of ISDN.

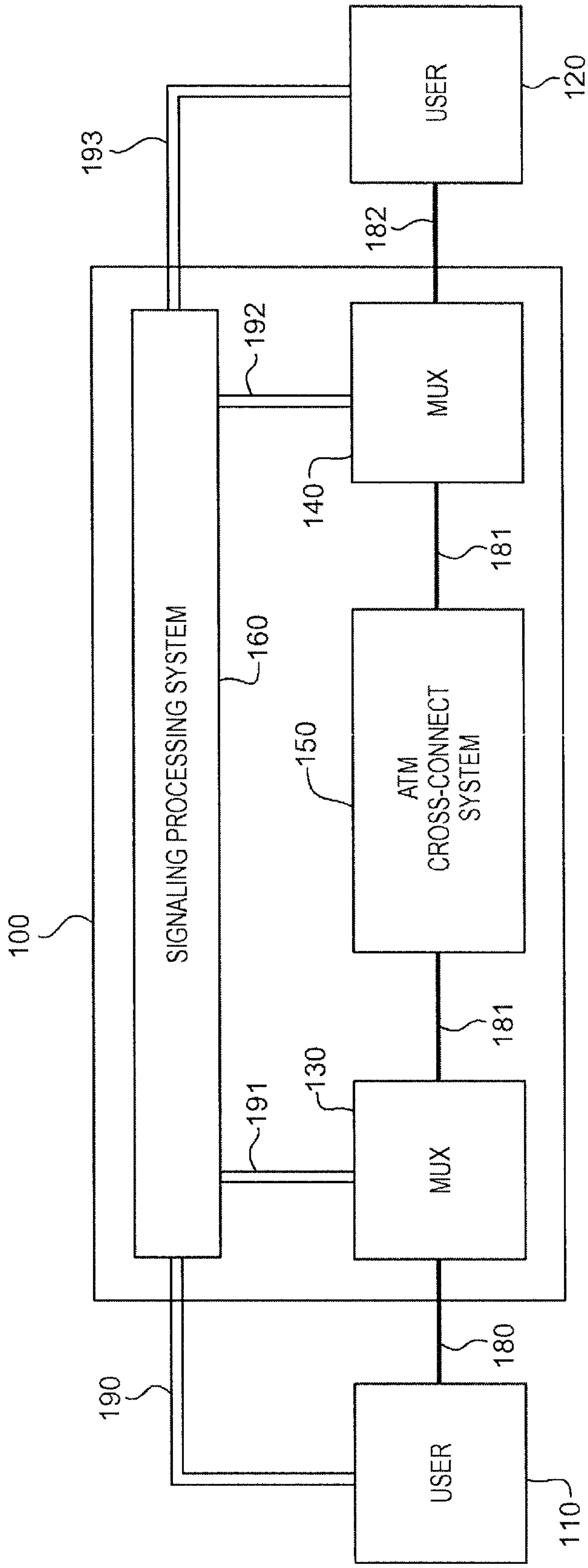
ITU–T Recommendation H.200 (Mar. 1993) Framework for Recommendations for Audiovisual Services.

Palmer, Rob, "An Experimental ATM Network for B–ISDN Research," IEEE 1992, Melbourne, Australia.

Dingle, Barry T., ISDN Signalling Control Part (ISCP) Telecom Australia Research Laboratories, Australian Broadband Switching and Services Symposium, 1992.

Sutherland, S. L., "Broadband ISDN Interworking" Australian Broadband Switching and Services Symposium, Melbourne, Jul. 1992.

* cited by examiner


USER
120
193
182
MUX
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140
181
SIGNALING PROCESSING SYSTEM
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ATM
CROSS-CONNECT
SYSTEM
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181
130
191
MUX
180
190
USER
110

FIG. 1

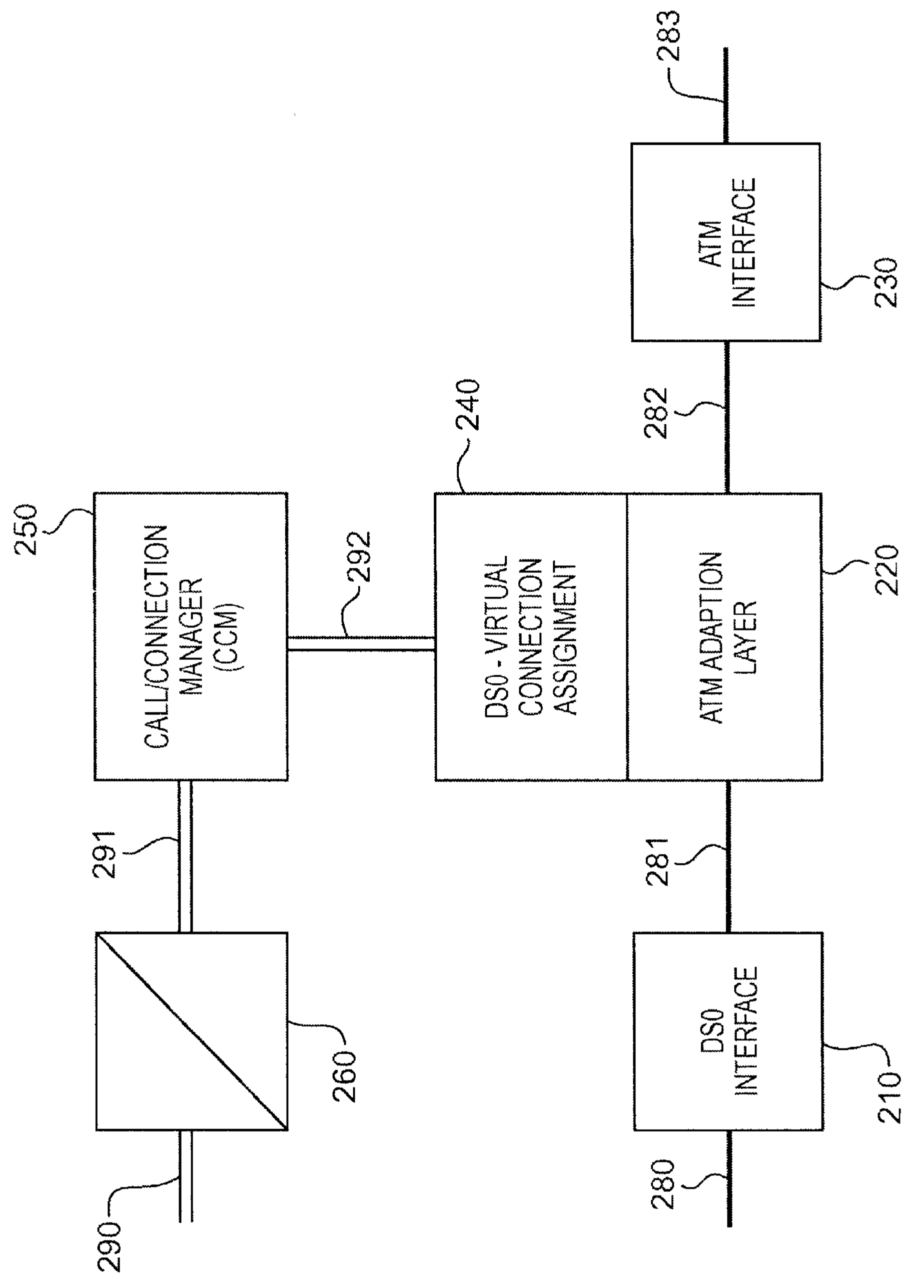

CALL/CONNECTION MANAGER (CCM)
250
291
292
260
290
DS0 - VIRTUAL CONNECTION ASSIGNMENT
240
ATM ADAPTION LAYER
220
ATM INTERFACE
230
DS0 INTERFACE
210
280
281
282
283

FIG. 2

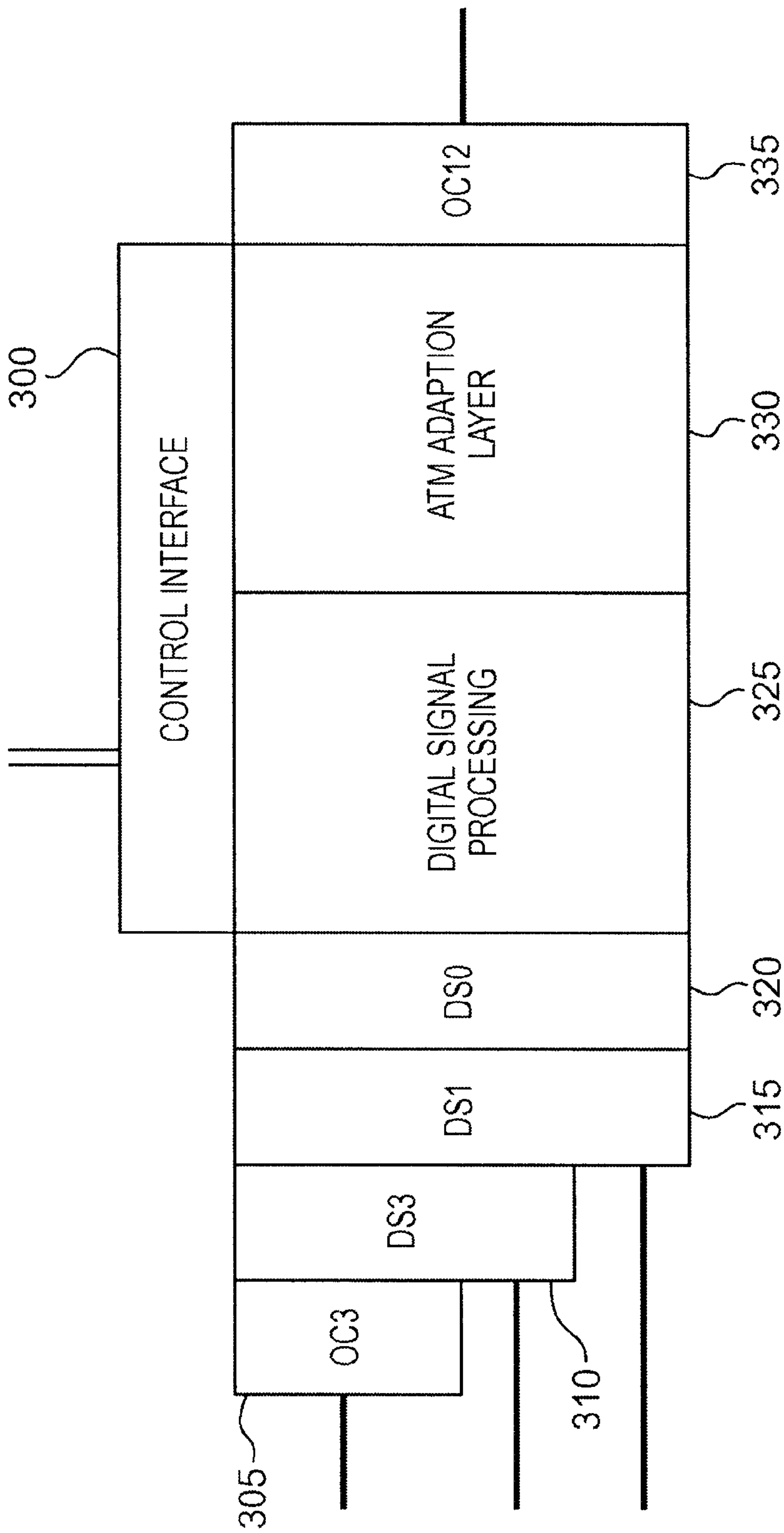

300
CONTROL INTERFACE
OC12
335
ATM ADAPTION LAYER
330
DIGITAL SIGNAL PROCESSING
325
DS0
320
DS1
315
DS3
OC3
310
305

FIG. 3

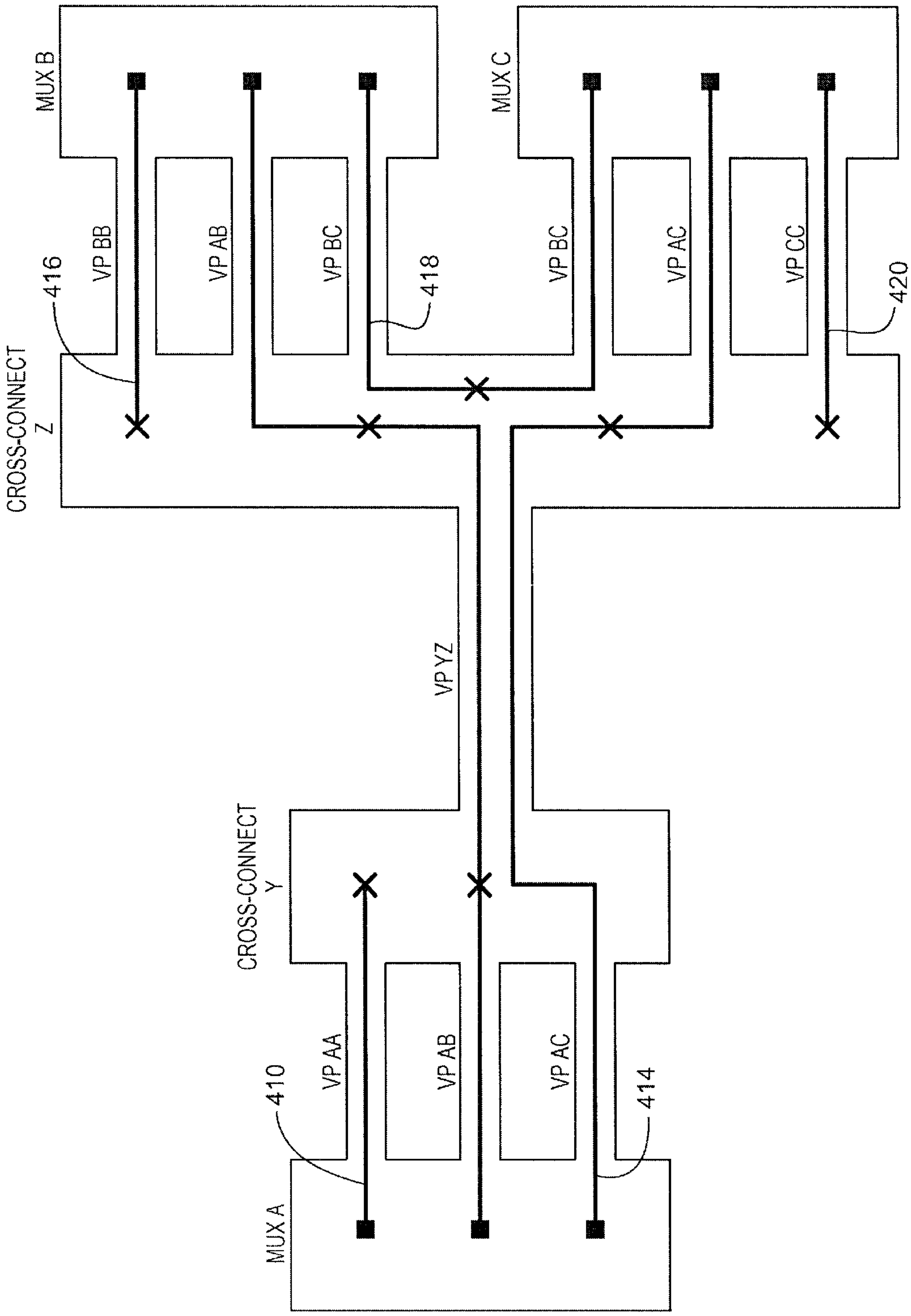
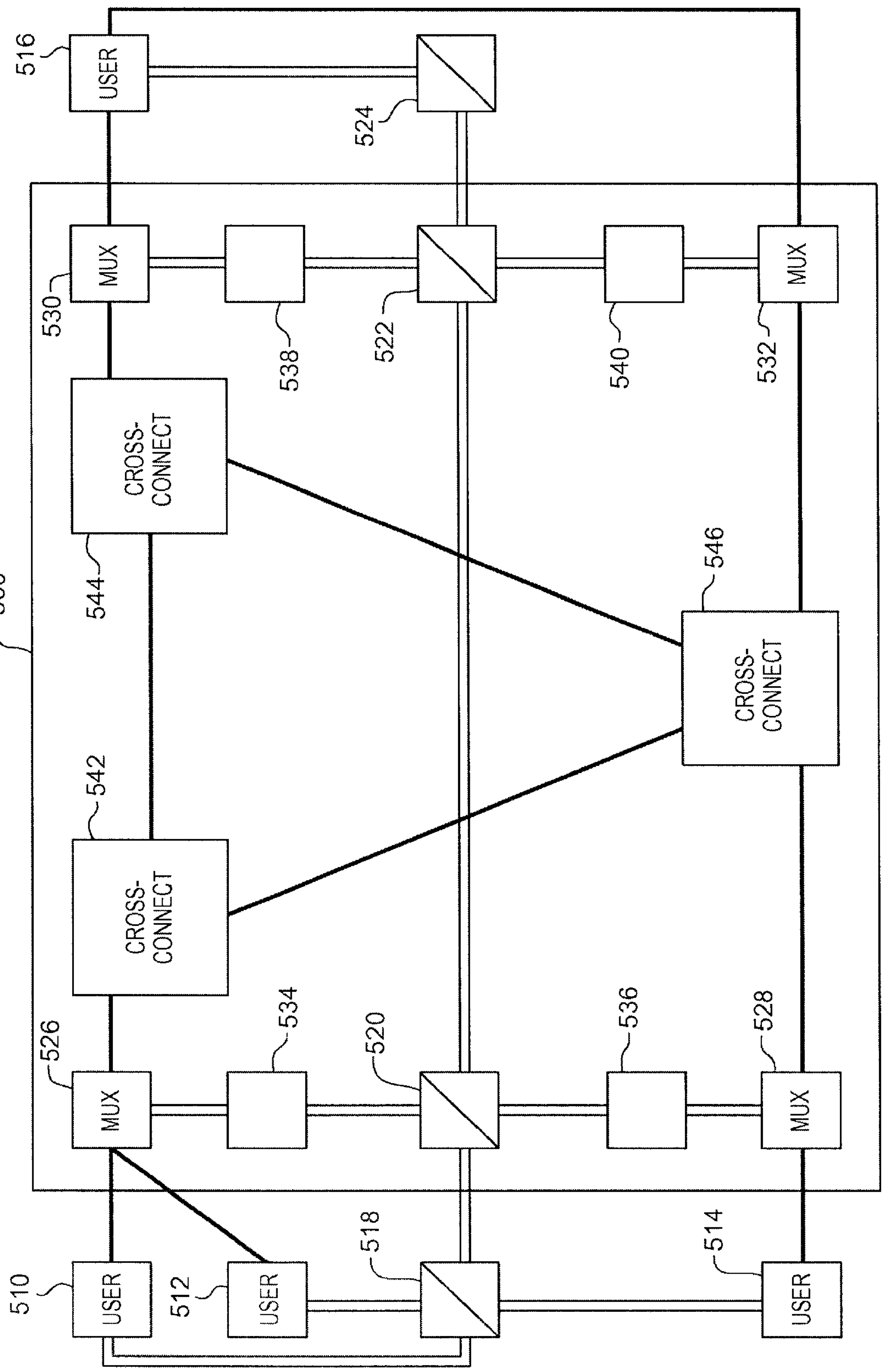

MUX B
MUX C
VP BB
VP AB
VP BC
VP BC
VP AC
VP CC
416
418
420
CROSS-CONNECT
Z
VP YZ
CROSS-CONNECT
Y
VP AA
VP AB
VP AC
410
414
MUX A

FIG. 4


516
USER
524
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MUX
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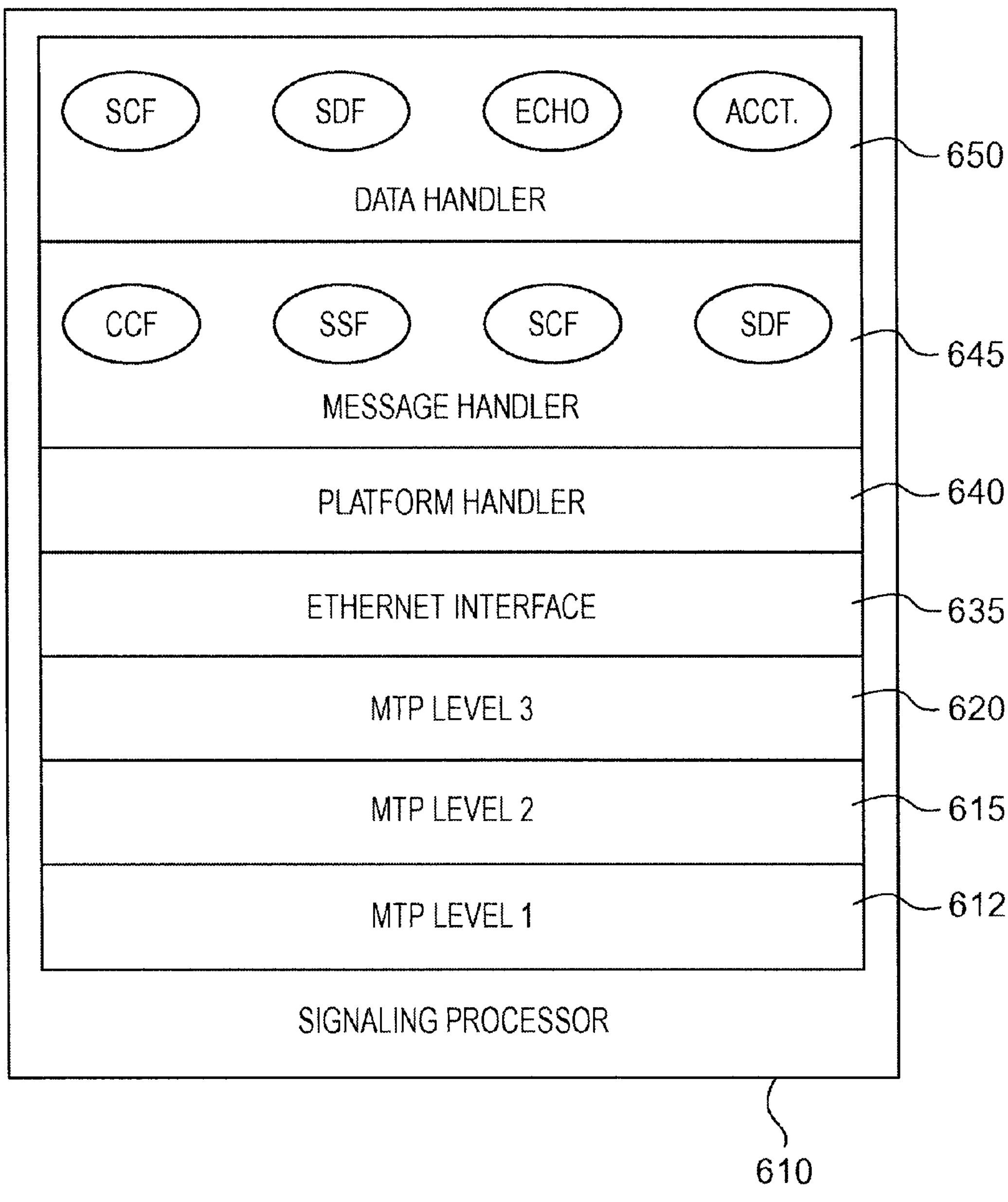
522
540
532
MUX
CROSS-CONNECT
544
500
546
CROSS-CONNECT
542
CROSS-CONNECT
526
MUX
534
520
536
528
MUX
518
514
510
USER
512
USER
USER

FIG. 5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SDF
ECHO
ACCT.
DATA HANDLER
650
CCF
SSF
SCF
SDF
MESSAGE HANDLER
645
PLATFORM HANDLER
640
ETHERNET INTERFACE
635
MTP LEVEL 3
620
MTP LEVEL 2
615
MTP LEVEL 1
612
SIGNALING PROCESSOR
610

FIG. 6

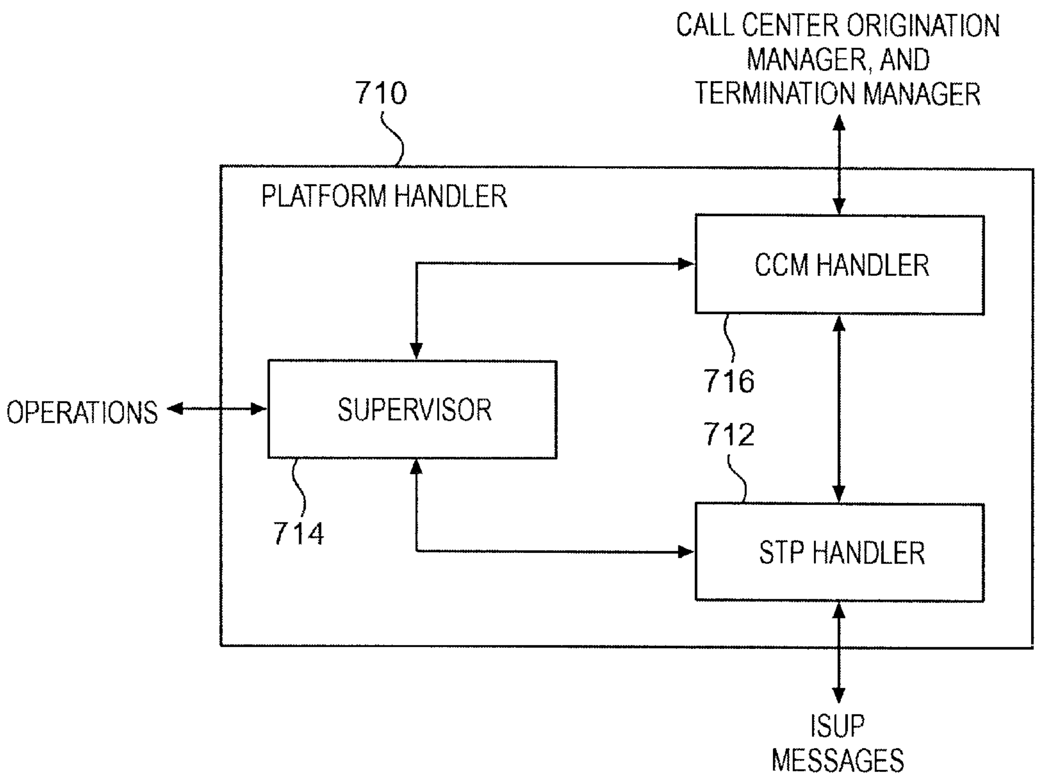

CALL CENTER ORIGINATION
MANAGER, AND
TERMINATION MANAGER
710
PLATFORM HANDLER
CCM HANDLER
716
OPERATIONS
SUPERVISOR
712
714
STP HANDLER
ISUP
MESSAGES

FIG. 7

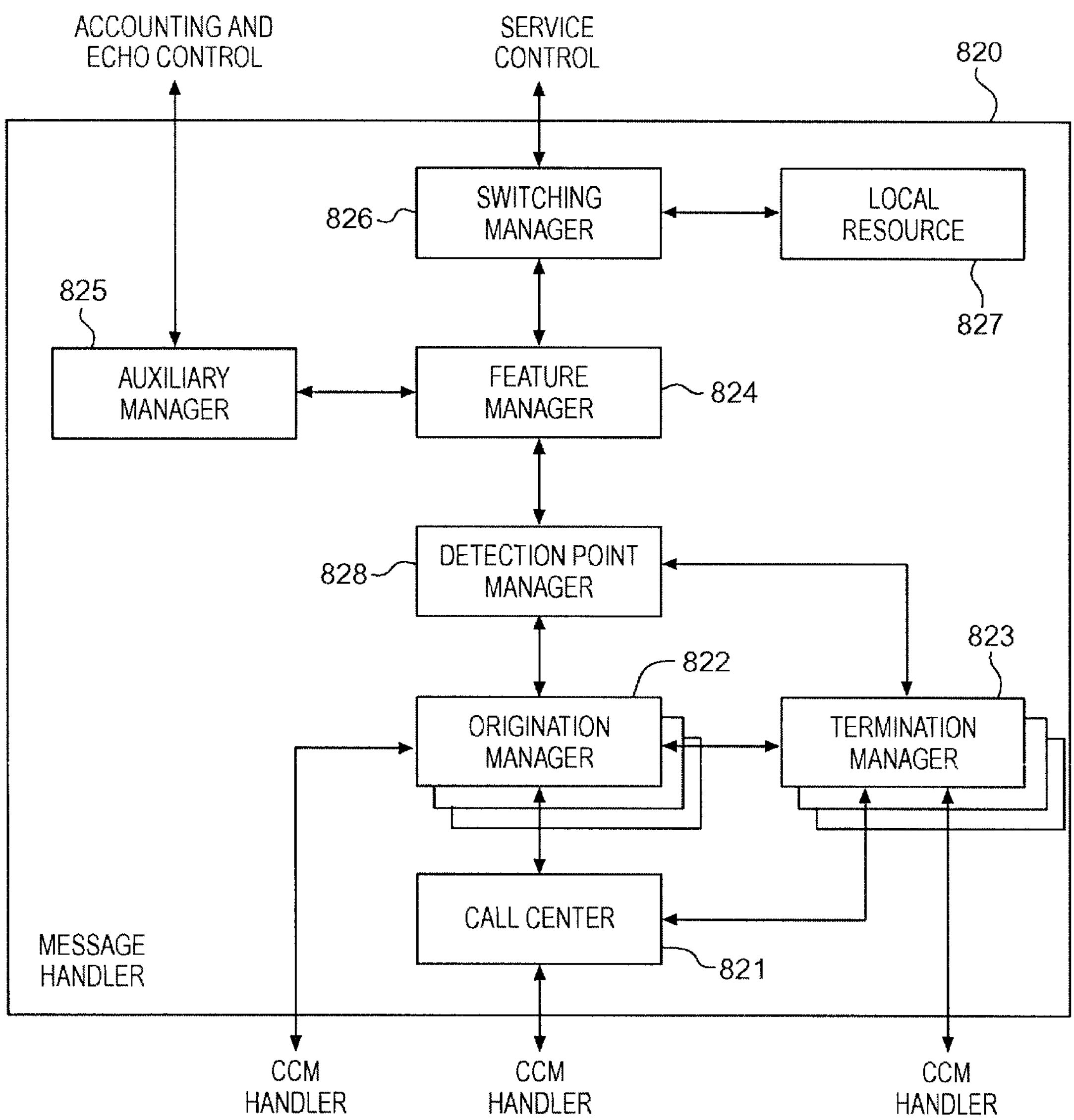

ACCOUNTING AND
ECHO CONTROL
SERVICE
CONTROL
820
826
SWITCHING
MANAGER
LOCAL
RESOURCE
827
825
AUXILIARY
MANAGER
FEATURE
MANAGER
824
828
DETECTION POINT
MANAGER
823
822
ORIGINATION
MANAGER
TERMINATION
MANAGER
CALL CENTER
821
MESSAGE
HANDLER
CCM
HANDLER
CCM
HANDLER
CCM
HANDLER

FIG. 8

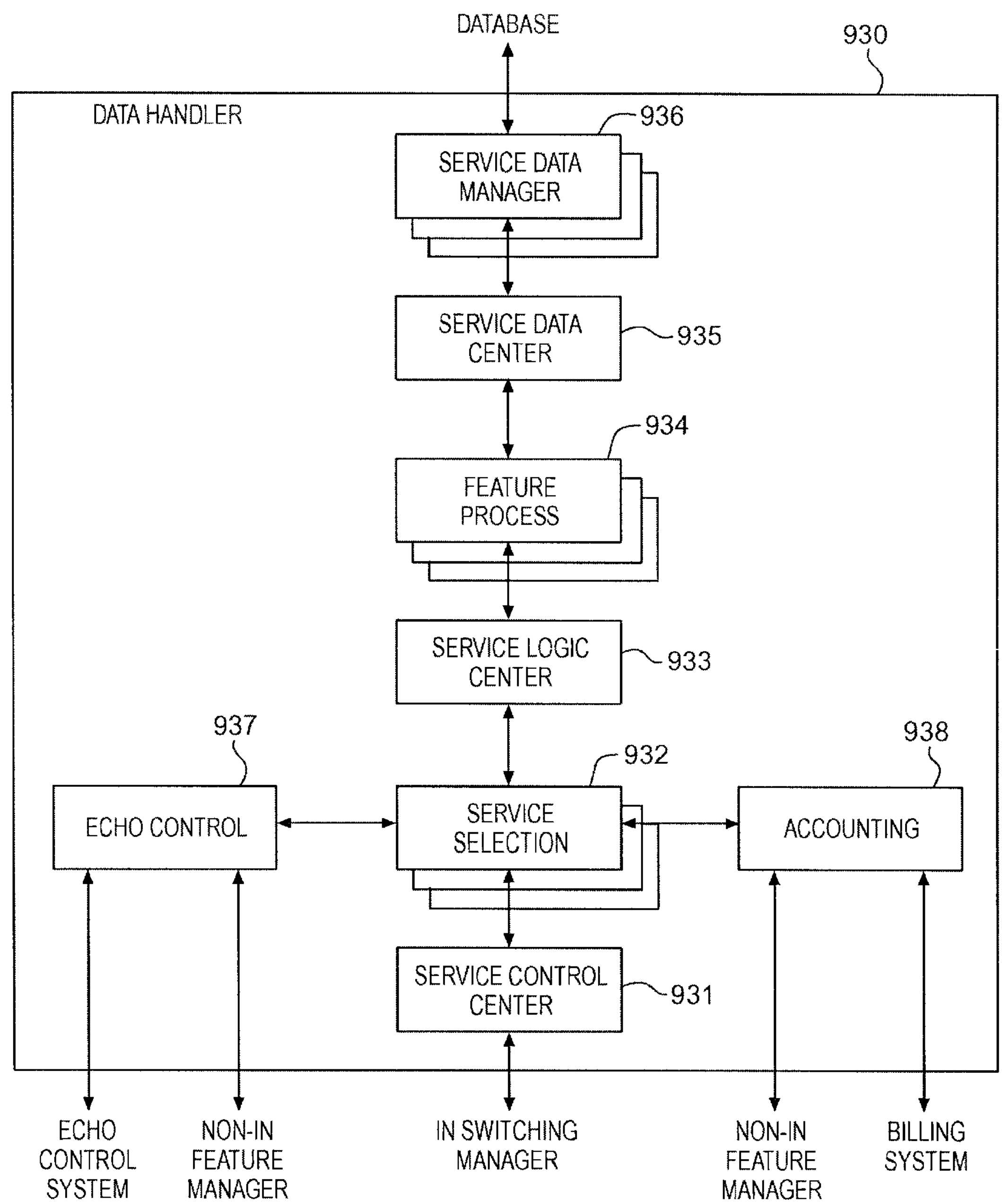

DATABASE
930
DATA HANDLER
936
SERVICE DATA MANAGER
SERVICE DATA CENTER
935
934
FEATURE PROCESS
SERVICE LOGIC CENTER
933
937
938
932
ECHO CONTROL
SERVICE SELECTION
ACCOUNTING
SERVICE CONTROL CENTER
931
ECHO CONTROL SYSTEM
NON-IN FEATURE MANAGER
IN SWITCHING MANAGER
NON-IN FEATURE MANAGER
BILLING SYSTEM

FIG. 9

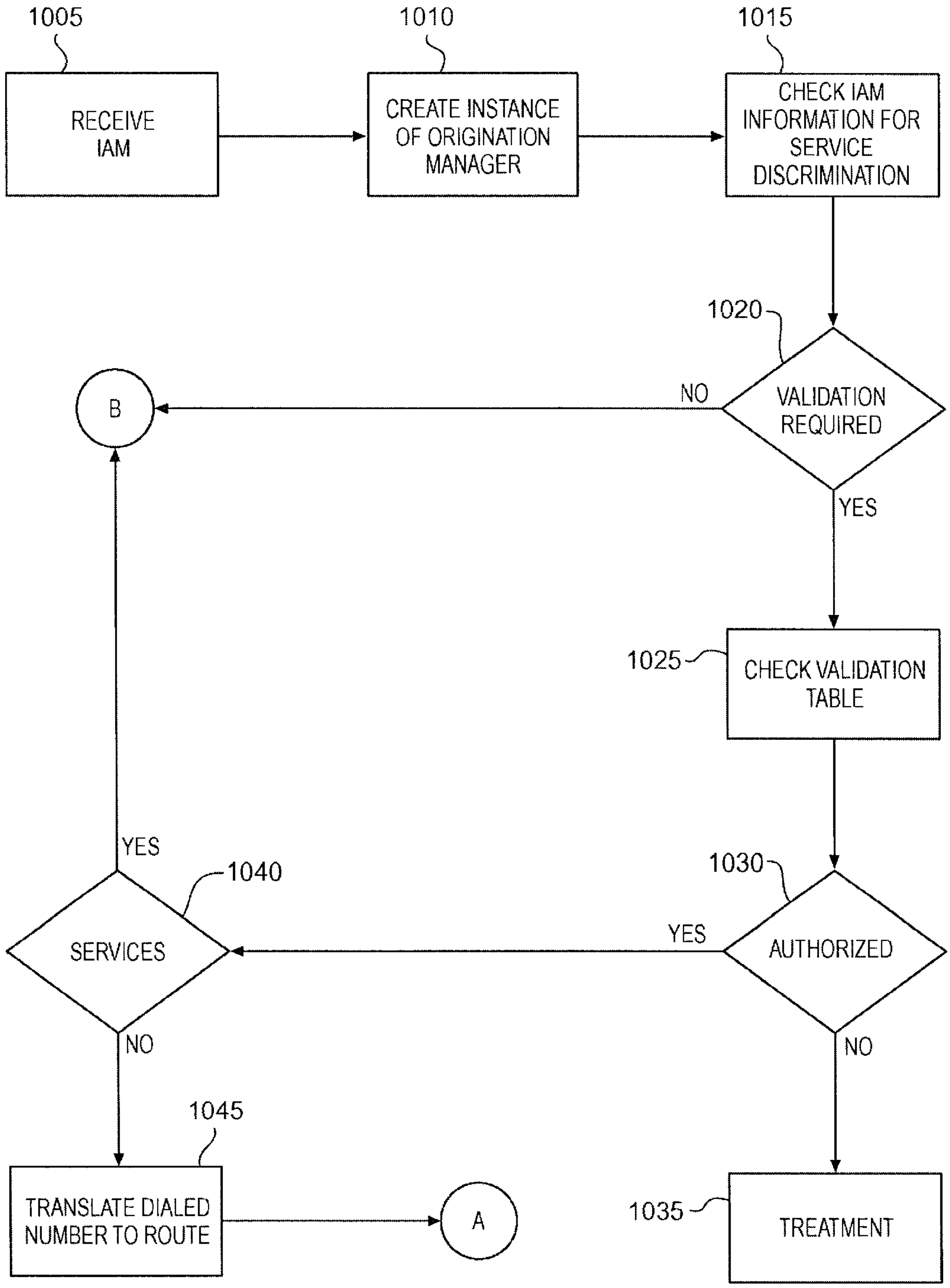
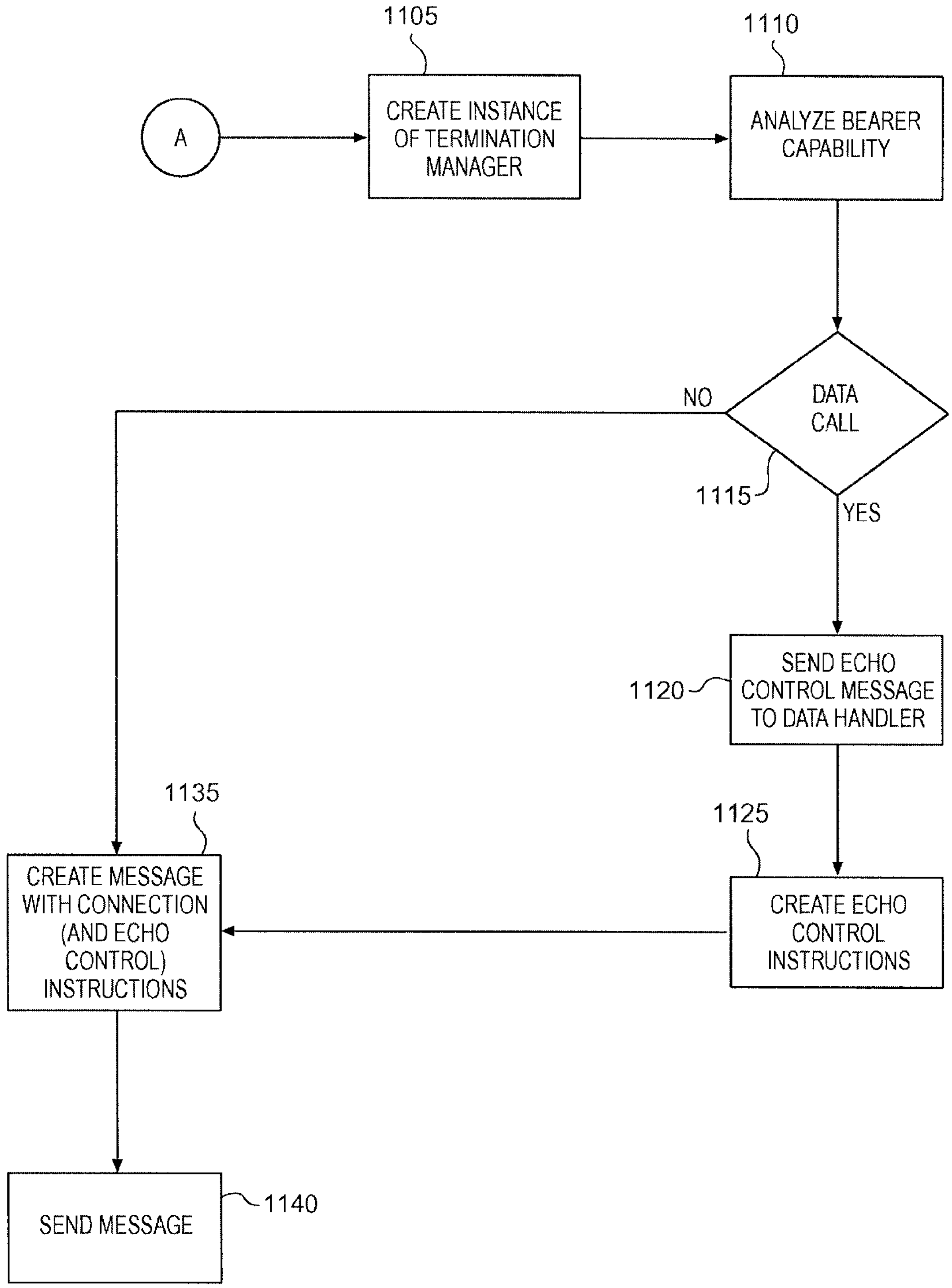

1005
RECEIVE IAM
1010
CREATE INSTANCE OF ORIGINATION MANAGER
1015
CHECK IAM INFORMATION FOR SERVICE DISCRIMINATION
1020
VALIDATION REQUIRED
NO
B
YES
1025
CHECK VALIDATION TABLE
1030
AUTHORIZED
YES
NO
1035
TREATMENT
1040
SERVICES
YES
NO
1045
TRANSLATE DIALED NUMBER TO ROUTE
A

FIG. 10



1105
1110
A
CREATE INSTANCE OF TERMINATION MANAGER
ANALYZE BEARER CAPABILITY
NO
DATA CALL
1115
YES
1120
SEND ECHO CONTROL MESSAGE TO DATA HANDLER
1135
1125
CREATE MESSAGE WITH CONNECTION (AND ECHO CONTROL) INSTRUCTIONS
CREATE ECHO CONTROL INSTRUCTIONS
SEND MESSAGE
1140

FIG. 11

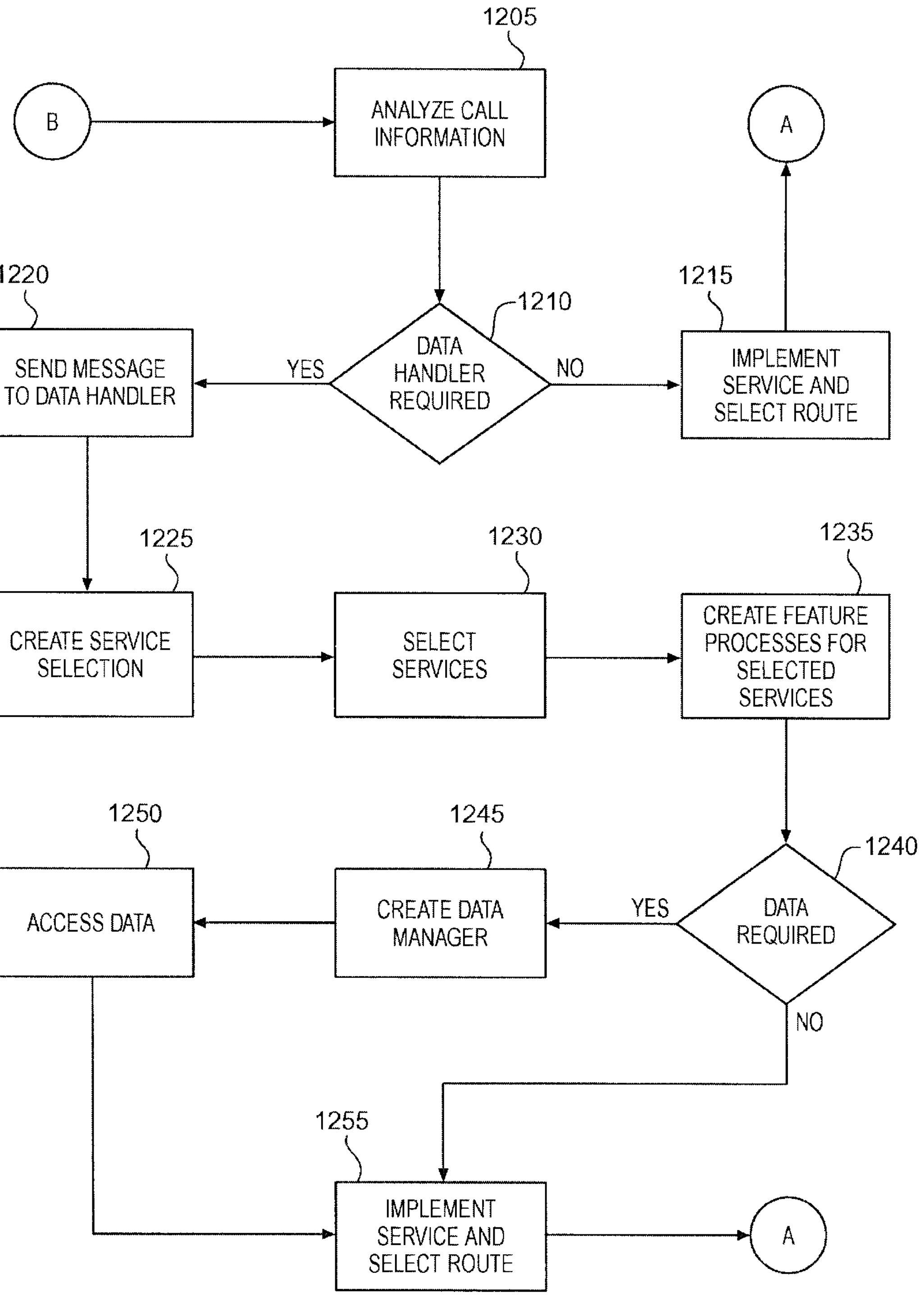

1205
B
ANALYZE CALL INFORMATION
A
1220
1210
1215
SEND MESSAGE TO DATA HANDLER
YES
DATA HANDLER REQUIRED
NO
IMPLEMENT SERVICE AND SELECT ROUTE
1225
1230
1235
CREATE SERVICE SELECTION
SELECT SERVICES
CREATE FEATURE PROCESSES FOR SELECTED SERVICES
1250
1245
1240
ACCESS DATA
CREATE DATA MANAGER
YES
DATA REQUIRED
NO
1255
IMPLEMENT SERVICE AND SELECT ROUTE
A

FIG. 12

BROADBAND TELECOMMUNICATIONS SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of pending U.S. patent application Ser. No. 08/525,897, entitled "Broadband Telecommunications System", filed on Sep. 8, 1995 now U.S. Pat. No. 5,991,301, which is incorporated by reference into this application, and which is a continuation-in-part application Ser. No. 08/568,551 filed Dec. 7, 1995 now U.S. Pat. No. 5,825,780 entitled "Method, System, and Apparatus for Telecommunications Control", which is incorporated by reference into this application, and which is a continuation of U.S. patent application Ser. No. 08/238,605 filed May 3, 1994.

BACKGROUND

At present, Asynchronous Transfer Mode (ATM) technology is being developed to provide broadband switching capability. Some ATM systems have used ATM cross-connects to provide virtual connections. Cross-connect devices do not have the capacity to process signaling. Signaling refers to messages that are used by telecommunications networks to set-up and tear down calls. Thus, ATM cross-connects cannot make connections on a call by call basis. As a result, connections through cross-connect systems must be pre-provisioned. They provide a relatively rigid switching fabric. Due to this limitation, ATM cross-connect systems have been primarily used to provide dedicated connections, such as permanent virtual circuits (PVCs) and permanent virtual paths (PVPs). But, they do not to provide ATM switching on a call by call basis as required to provide switched virtual circuits (SVCs) or switched virtual paths (SVPs). Those skilled in the art are well aware of the efficiencies created by using SVPs and SVCs as opposed to PVCs and PVPs. SVCs and SVPs utilize bandwidth more efficiently.

ATM switches have also been used to provide PVCs and PVPs. Since PVCs and PVPs are not established on a call-by call basis, the ATM switch does need to use its call processing or signaling capacity. ATM switches require both signaling capability and call processing capability to provide SVCs and SVPs. In order to achieve virtual connection switching on a call by call basis, ATM switches are being developed that can process calls in response to signaling to provide virtual connections for each call. These systems cause problems because they must be very sophisticated to support current networks. These ATM switches must process high volumes of calls and transition legacy services from existing networks. An example would be an ATM switch that can handle large numbers of POTS, 800, and VPN calls. This generation of sophisticated ATM switches is not yet mature and should be expensive when they are first deployed.

Currently, ATM multiplexers are being developed that can interwork traffic into ATM cells and multiplex the cells for transport over an ATM network. One example of an application of these muxes is provided by T1 transport over an ATM connection. Traffic that leaves the switch in T1 format is muxed into ATM cells for transport over a high speed connection. Before the cells reach another switch, they are converted back into the T1 format. Thus, the ATM mux is used for high speed transport. The ATM mux is not used to select virtual connections on a call-by-call basis. Unfortunately, there is not a telecommunications system that

can provide ATM switching on a call by call basis without relying on the call processing and signaling capability of an ATM switch.

SUMMARY

The invention includes a method of operating a telecommunications system to provide a call with a virtual connection. The method is for use when a user places the call by sending signaling for the call to the telecommunications system and by transmitting user information to the telecommunications system over a particular connection. The system comprises an ATM interworking multiplexer and a signaling processor linked to the ATM interworking multiplexer. The method comprises receiving the signaling for the call into the signaling processor, processing the signaling to select the virtual connection, generating new signaling to identify the particular connection and the selected virtual connection, and then transmitting the new signaling to the ATM interworking multiplexer. The method also includes receiving the user information for the call from the particular connection into the ATM interworking multiplexer, converting the user information into ATM cells that identify the selected virtual connection in response to the new signaling, and transmitting the ATM cells over the selected virtual connection. The signaling for the call could be a call set-up message, such a Signaling System #7 (SS7) initial address message (IAM). The method could also include applying digital signal processing (DSP) to the call in the multiplexer in accord with DSP requirements selected by the signaling processor. DSP requirements could include echo control or encryption.

The invention also includes a telecommunications system to provide a call with a virtual connection in response to signaling for the call. The system comprises a signaling processor to receive and process signaling to select the virtual connection for the call, and to generate and transmit new signaling that identifies the selected virtual connection. The system includes an ATM interworking multiplexer to receive user information from a connection, convert the user information into ATM cells that identify the selected virtual connection, and transmit the ATM cells over the selected virtual connection. The system could also include an ATM cross-connect system connected to the ATM interworking multiplexer and configured to provide a plurality of virtual connections to the ATM interworking multiplexer.

The invention also includes an ATM interworking multiplexer for providing calls with virtual connections in response to signaling for each of the calls. The multiplexer comprises an access interface to receive user information for each call from a particular connection. It also includes a control interface to receive signaling for each call that identifies the particular connection and a virtual connection for that call. It also includes an ATM adaption processor to convert user information from the particular connection for each call into ATM cells that identify the virtual connection for that call. The multiplexer also includes an ATM interface to transmit the ATM cells for each call over the virtual connection. The multiplexer could include a digital signal processor to apply digital signal processing to the user information for each call. The processing could include echo control and encryption.

In various embodiments, the invention accepts calls placed over DS0 voice connections and provides virtual connections for the calls. In this way, broadband virtual connections can be provided to narrowband traffic on a call-by-call basis without requiring the call processing and signaling capability of an ATM switch.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of a version of the present invention.

FIG. **2** is a block diagram of a version of the present invention.

FIG. **3** is a block diagram of a version of the present invention.

FIG. **4** is a block diagram of a version of the present invention.

FIG. **5** is a block diagram of a version of the present invention.

FIG. **6** depicts a logic diagram of a version of the invention.

FIG. **7** depicts a logic diagram of a version of the invention.

FIG. **8** depicts a logic diagram of a version of the invention.

FIG. **9** depicts a logic diagram of a version of the invention.

FIG. **10** depicts a flow diagram of a version of the invention.

FIG. **11** depicts a flow diagram of a version of the invention.

FIG. **12** depicts a flow diagram of a version of the invention.

DETAILED DESCRIPTION

For purposes of clarity, the term "connection" will be used to refer to the transmission media used to carry user traffic. The term "link" will be used to refer to the transmission media used to carry signaling. On the Figures, connections are shown by a single line and signaling links are shown by double lines.

FIG. **1** depicts a version of the present invention. Shown is telecommunications system **100**, user **110**, and user **120**. Telecommunications system **100** includes ATM interworking multiplexer (mux) **130**, mux **140**, ATM cross-connect system **150**, and signaling processing system **160**. User **110** is connected to mux **130** by connection **180**. Mux **130** and mux **140** are connected through cross-connect system **150** by connection **181**. Mux **140** is connected to user **120** by connection **182**. Signaling processing system **160** is linked to user **110** by link **190**, to mux **130** by link **191**, to mux **140** by link **192**, and to user **120** by link **193**.

Those skilled in the art are aware that large networks have many more components than are shown. For example, there would typically be a multitude of virtual connections through ATM cross-connect system **150**. The number of these components has been restricted for clarity. The invention is fully applicable to a large network.

User **110** and user **120** could be any entity that supplies telecommunications traffic to in network **100**. Some examples would be a local exchange carrier (LEC) switch or customer premises equipment (CPE). Typically, the user traffic would be provided to system **100** in DS3, DS1, or OC-3 format that have embedded DS0 and VT1.5 circuits. Connections **180** and **182** represent any connection that might be used by user **120** to access system **100** and would also include formats such as E1, E3, and DS2. As such, these connections are periodically referred to as access connections. Connections **180** and **182** would typically be DS0 connections embedded within a DS3 connection, however, the invention fully contemplates other connection being used with a few examples being a fractional DS1, a clear DS3, or even SONET OC-3. Links **190** and **193** are any links capable of transferring signaling messages with an example being Signaling System #7 (SS7) links. ATM cross-connect system **150** is any system that provides a plurality of virtual connections. Such a system could be comprised of individual ATM cross-connect devices interconnected by ATM connections using DS3 or SONET for transport. An example of an ATM cross-connect is the NEC Model 10. Connection **181** could be any virtual connection. Typically, the virtual connection would use DS3 or SONET for transport. ATM cross-connect system **150** would be pre-provisioned to provide a plurality of virtual connections through the cross-connect system, and virtual connection **181** represents one of these connections. As virtual connections are logical paths, many physical paths can be used based on the pre-provisioning of ATM cross-connect system **150**. Links **191** and **192** could be any links capable of transporting data messages. Examples of such links could be SS7 or UDP/IP. The components described in this paragraph are known in the art.

Signaling processing system **160** is any processing platform that can receive and process signaling to select virtual connections, and then generate and transmit signaling to identify the selections. Various forms of signaling are contemplated by the invention, including SS7, C7, and user to network interface (UNI) signaling. A preferred embodiment of the signaling processor is discussed in detail toward the end of the disclosure.

Mux **130** could be any muxing system operable to place user information arriving over connection **180** on the virtual connection selected by signaling processing system **160**. Typically, this involves receiving signaling messages from signaling processing system **160** that identify assignments of virtual connections to an access connection on a call by call basis. The mux would convert user traffic from access connection **180** into ATM cells that identify the selected virtual connection. Mux **140** is similar to mux **130**. A preferred embodiment of these muxes are also discussed in detail below.

The system would operate as follows for a call from user **110** to user **120**. User **110** would send a signaling message over link **190** to system **100** initiating the call. Signaling processing system **160** would process the message. Such processing could include validation, screening, translating, route selection, echo control, network management, signaling, and billing. In particular, a virtual connection through ATM cross-connect system **150** from mux **130** to mux **140** would be selected, and a connection from mux **140** to user **120** would also be selected. Although many possible connections would be available, only the selected connections are shown—connection **181** and connection **182**. Generally, the selection is based on the dialed number, but call processing can entail many other factors with a few examples being network loads and user routing instructions. Signaling processing system **160** would then send signaling reflecting the selections to mux **130** and mux **140**.

User **110** would also seize a connection to system **100**. The connection is represented by connection **180** to mux **130**. Although, only one connection is shown for purposes of clarity, numerous connections would typically be available for seizure. The seized connection would be identified in the signaling from user **110** to system **100**. Signaling processing system **160** would include the identity of this connection in its signal to mux **130**.

If required, user **120** would receive signaling to facilitate completion of the call. The signaling from signaling pro-

cessing system **160** would indicate that system **100** was connecting to user **120** over connection **182**. Typically, user **120** would accept and acknowledge the connection in a signaling message back to system **100**.

Mux **130** would receive signaling from signaling processing system **160** identifying connection **180** as the access connection and connection **181** as the selected virtual connection through ATM cross-connect system **150**. Mux **130** would convert the user information from connection **180** into ATM cells. Mux **130** would designate connection **181** in the cell headers. Connection **181** would have been previously provisioned through ATM cross-connect system **150** from mux **130** to mux **140**.

Mux **140** would receive signaling from signaling processing system **160** identifying connection **181** as the selected virtual connection and connection **182** as the selected access connection to user **120**. Mux **140** would convert cells arriving on connection **181** to user information suitable for connection **182** to user **120**. Although the above example employs two muxes, a single mux could be employed for calls that enter and exit system **100** through the same mux. In this case, the ATM system would simply provide a virtual connection back to the same mux.

From the above discussion, it can be seen that multiple virtual connections can be pre-provisioned through an ATM cross-connect system to interconnect ATM interworking multiplexers. When a user places a call, one of the virtual connections is selected for the call by the signal processing system and identified to the appropriate muxes. The muxes convert the user information into cells that identify the selected connection. As such, user information can be switched through an ATM fabric on a call by call basis. The system does not require the call processing or signaling capabilities of an ATM switch (although an ATM switch could be used to provide the virtual connections without using its call processing and signaling functions). The system can also implement enhanced services such as N00 and virtual private network (VPN).

FIG. **2** depicts another embodiment of the invention. In this embodiment, the user information from the access connection is capable of being muxed to the DS0 level, but this is not required in other embodiments. Additionally, SS7 signaling is used in this embodiment, but other signaling protocols, such as C7 or UNI signaling, are also applicable to the invention.

Shown are DS0 interface **210**, ATM adaption layer (AAL) **220**, ATM interface **230**, DS0—virtual connection assignment **240**, call/connection manager (CCM) **250** and signal transfer point (STP) **260**. Also shown are connections **280–283** and links **290–292**.

Connection **280** could by any connection or group of connections that contain information that can be converted to DS0 format. Examples of these connections are OC-3, VT1.5, DS3, and DS1. DS0 interface **210** is operable to convert user information in these formats into the DS0 format. AAL **220** comprises both a convergence sublayer and a segmentation and reassembly (SAR) layer. AAL **220** is operational to accept the user information in DS0 format from DS0 interface **210** and convert the information into ATM cells. AALs are known in the art and information about AALs is provided by International Telecommunications Union (ITU) document I.363.1. An AAL for voice is also described in U.S. patent application Ser. No. 08/395,745, filed on Feb. 28, 1995, entitled "Cell Processing for Voice Transmission", and hereby incorporated by reference into this application. ATM interface **230** is operational to accept ATM cells and transmit them over connection **283**. Connection **283** is a standard DS3 or SONET connection transporting ATM cells. Connection **281** is operational for the DS0 format and connection **282** is operational to transfer ATM cells.

It can be seen that a communications path through connections **280–283** could be established to carry user information. Although the communications path has been described from connection **280** to connection **283**, the invention contemplates components that are also operational to perform reciprocal processing in the reverse direction. If the communications path is bidirectional, user information in ATM cells arriving on connection **283** would be processed for output on connection **280** in the appropriate format. Those skilled in the art will appreciate that separate connections could also be set up in each direction, or that only a connection in one direction may be required. These components and their operation are known in the art.

Signaling links **290** and **291** are SS7 links. Link **292** is a data link with an example being an ethernet connection transporting UDP/IP. STP **260** is device that routes signaling messages. STPs are well known in the art. CCM **250** would be identified by its own signaling point code. STP **260** would route signaling messages addressed to this point code to CCM **250**. In some embodiments, STP **260** may also convert other point codes to the point code for CCM **250** so these signaling messages are also routed to CCM **250**. Although point code conversion is not essential, it facilitates the transition of a network to the system of the invention. The conversion could be implemented through a conversion table located between level 2 and level 3 of the message transfer part (MTP) function of STP **260**. The conversion table would convert the destination point code of the message to that of CCM **250**, so that the route function of MTP **3** would forward the message to CCM **250**. Point code conversion could be based on many factors with a few examples being the destination point code, the origination point code, the signaling link, the circuit identification code, the message type, and various combinations of these and other factors. For example, SS7 Integrated Services User Part (ISUP) messages with particular OPC/DPC combinations could have the DPC converted to the point code of CCM **250**. These signaling messages would then be routed to CCM **250** by STP **260**. One version of a suitable STP is disclosed in United States patent application entitled "Telecommunications Apparatus, System, and Method with Enhanced Signal Transfer Point", filed simultaneously If with this application, assigned to the same entity, and hereby incorporated by reference into this application.

CCM **250** is a signaling processor that operates as discussed above. A preferred embodiment of CCM **250** is provided later. In this embodiment CCM **250** would be operable to receive and process SS7 signaling to select connections, and to generate and transmit signaling identifying the selections.

Assignment **240** is a control interface that accepts messages from CCM **250**. In particular, assignment **240** identifies DS0/virtual connection assignments in the messages from link **292**. These assignments are provided to AAL **220** for implementation. As such, AAL **220** obtains the virtual path identifier (VPI) and virtual channel identifier (VCI) for each call from assignment **240**. AAL **220** also obtains the identity of the DS0 for each call (or the DS0s for an N×64 call). AAL **220** then converts user information between the identified DS0 and the identified ATM virtual connection. Acknowledgments that the assignments have been implemented may be sent back to CCM **250** if desired.

In operation, calls are processed as follows. Signaling messages for calls arrive on link **290** and are routed by STP **260** to CCM **250**. Access connections are typically seized contemporaneously with the signaling. All of these connections are represented by connection **280**. DS0 interface **210** would convert the traffic on connection **280** into the DS0 format and provide the DS0s to AAL **220** over connection **281**.

The signaling received by CCM **250** would identify the access connections for the calls (i.e. the particular DS0s on connection **280**), and contain call information, such as a dialed number. CCM **250** would process the signaling and select connections for the call. Since multiple virtual connections are pre-provisioned from ATM interface **230** to the other destinations in the network, CCM **250** can select a virtual connection to the destination. The selection process can be accomplished through table look-ups. For example, a table could be used to translate a portion of the dialed number into a VPI. The VCI would be selected based on the available VCIs in the selected VPI. The VPI/VCI combination would correspond to a unique virtual connection pre-provisioned from ATM interface **230** to the appropriate network destination. The selections represent the DS0—virtual connection assignments that are provided to assignment **240** over link **292**.

Assignment **240** accepts the DS0—virtual connection assignments and provides them to AAL **220**. When AAL **220** receives a particular assignment, it converts user information from the designated DS0 into cells that identify the designated VPI/VCI. The cells are provided to ATM interface **230** over connection **282**. ATM interface **230** accepts the cells and places them within the transport format for connection **283**. The cells are then transported over the selected virtual connection to the appropriate destination.

Calls also exit the network through connection **280**. In this case, CCMs at the origination points select the virtual connections to ATM interface **230**. The originating CCMs also send signaling messages to CCM **250**. The signaling messages identify the destinations for the calls and the selected virtual connections. CCM **250** will have a list of available access connections to the identified destinations. CCM **250** will select the access connections to the destination from the list. For example, the connection selected by CCM **250** could be a DS0 embedded within a DS3 connected to a LEC. The virtual connections on connection **283** and selected access connections on connection **280** are provided to assignment **240** over link **292**. Assignment **240** provides these assignments to AAL **220**.

ATM interface **230** will demux the cells arriving from connection **283** and provide them to AAL **220**. AAL **2**converts the user information in the cells into the DS0 format. AAL **220** make the conversion so that cells from a particular virtual connection are provided to the assigned DS0 on connection **281**. DS0 interface will convert the DS0s from connection **281** into the appropriate format, such as DS3, for connection **280**. Those skilled in the art are aware of the techniques for muxing and transporting DS0 signals.

From the above discussion, it can be seen that user information for calls can flow from connection **280** to connection **283**, and in the reverse direction from connection **283** to connection **280**. DS0 interface **210** and ATM interface **230** provide user information in their respective formats to AAL **220**. AAL **220** converts the user information between DS0 and ATM formats based on the assignments from assignment **240**. CCM **250** can select the DS0—virtual connection assignments that drive the process.

The ATM Interworking Multiplexer

FIG. **3** shows one embodiment of the mux that is suitable for the present invention, but muxes that support the requirements of the invention are also applicable. Shown are control interface **300**, OC-3 interface **305**, DS3 interface **310**, DS1 interface **315**, DS0 interface **320**, digital signal processing (DSP) **325**, AAL **330**, and OC-12 interface **335**.

OC-3 interface **305** accepts the OC-3 format and makes the conversion to DS3. DS3 interface **310** accepts the DS3 format and makes the conversion to DS1. DS3 interface **310** can accept DS3s from OC-3 interface **305** or from an external connection. DS1 interface **315** accepts the DS1 format and makes the conversion to DS0. DS1 interface **315** can accept DS1s from DS3 interface **310** or from an external connection. DS0 interface **320** accepts the DS0 format and provides an interface to digital signal processing (DSP) **325**.

DS0 interface **320** is coupled to DSP **325**. DSP **325** is capable of manipulating the user information to improve transmission quality. DSP processing primarily entails echo cancellation, but could include other features as well. As is known, echo cancellation can be required for voice calls. DSP **325** passes the DS0s through echo cancellers. These echo cancellers must be disabled for calls that do not require echo control. Data calls do not require echo cancellation, and the CCM has the ability to recognize data calls that require an echo canceller to be disabled. The CCM will send a control message through control interface **300** to DSP **325** indicating the particular echo canceller that is to be disabled. The CCM selects the echo canceller based on the CIC in the signaling it receives from the user. After the data call, the CCM sends a message that causes the particular echo canceller to be enabled again for subsequent voice calls. The above technique of applying echo control is preferred, but other means of implementing echo control instructions from the CCM are also applicable.

In addition to echo control, the CCM and the mux can work to provide other digital signal processing features on a call by call basis. Compression algorithms can be applied, either universally, or on a per call basis. The decibel level could be adjusted for calls form a particular origin or to a particular destination, i.e. where a hearing impaired person may reside. Encryption could be applied on a call-by-call basis based on various criteria like the origination number or the destination number. Various DSP features could be associated with various call perameters and implemented by the CCM through DSP **325**.

DSP **325** is connected to AAL **330**. AAL **330** operates as described above for an AAL. DS0—virtual connection assignments from control interface **300** are implemented by AAL **330** when converting between the DS0 and ATM formats.

Calls with a bit rate greater than 64 kbittsec. are known as N×64 calls. If desired, AAL **330** can be capable of accepting control messages through control interface **300** from the CCM for N×64 calls. The CCM would instruct AAL **330** to group the DS0s for the call.

The ATM Cross-connect System

FIG. **4** depicts virtual connections provided by the ATM cross connect system in a version of the invention, although numerous other techniques for providing virtual connections will be appreciated by one skilled in the art, and the invention contemplates any such system. Shown are virtual connections **410**, **412**, **414**, **416**, **418**, and **420**. These virtual connections are shown interconnecting muxes A, B, and C

through cross-connects Y and Z. Virtual connections are provisioned in between each mux. Each mux would have a virtual path to the cross-connect system that is designated for each possible destination mux. Virtual path AB contains virtual connection **412** from mux A to mux B. For calls that originate and terminate at the same mux, virtual connections **410**, **416**, and **420** are provisioned for that purpose. Virtual connections **414** and **418** connect muxes A/C and B/C respectively. Alternate routes for different virtual connections can be provisioned between the same two muxes.

Within each virtual path are thousands of virtual channels (not shown). Virtual connections are provisioned by cross-connecting VPI/VCI combinations at cross-connects Y and Z. If a call enters mux A and needs to terminate at mux B, the CCM will select virtual path AB. The selection could be based on a translation of the dialed number. Within virtual path AB, the CCM would select the particular virtual channel. This selection could be based on available VC1s within the VPI. In this way, pre-provisioned virtual connections can be selected on a call by call basis.

Typically, calls will require a bi-directional voice connection. For this purpose, a virtual connection must transport user information in both directions. The virtual connections can be provisioned so that the mux at the terminating end may use the same VPI/VCI for cells transported in the opposite direction. The terminating CCM could also translate the originating VPI/VCI into another VPI/VCI provisioned in the opposite direction and provide this VPI/VCI to the terminating mux.

Additionally, the number of active virtual connections in between cross-connects can be tracked. Virtual path YZ connects cross-connects Y and Z. The capacity of virtual path YZ would be sized based on network requirements, but should it become overloaded, the CCMs can be programmed to select an alternate virtual path.

Operation within a Network

FIG. **5** depicts an embodiment of the invention with respect to a specific telecommunications network scenario, although the invention is not limited to this specific scenario. FIG. **5** shows telecommunications system **500**. Shown are user **510**, user **512**, user **514**, user **516**, STP **518**, STP **520**, STP **522**, STP **524**, mux **526**, mux **528**, mux **530**, mux **532**, call/connection manager (CCM) **534**, CCM **536**, CCM **538**, CCM **540**, ATM cross-connect **542**, ATM cross-connect **544**, and ATM cross-connect **546**. For clarity, the connections and signaling links are not numbered. All of these components are described, and the CCMs are also discussed below.

In operation, user **510** may forward an 800 call to system **500**. User **510** could be connected to mux **526** with a DS3 connection. The 800 call would occupy a DS0 embedded in the DS3 connected to mux **526**. User **510** would send an SS7 Initial Address Message (IAM) through STP **518** to system **500**. STP **520** would be configured to route the IAM to CCM **534**. An IAM contains information such as the dialed number, the caller's number, and the circuit identification code (CIC). The CIC identifies the DS0 used by user **510** for the call.

CCM **534** would process the IAM and identify that the call was an 800 call. Either through its own database or by accessing a service control point (SCP) (not shown), the CCM would translate the dialed number based on the 800 subscriber's routing plan. For example, 800 calls from user **510** may be routed to user **512** during business hours, to user **514** at night, and to user **516** on weekends. If the call is placed from user **512** on a weekend, the call would be routed to user **516**. As such, CCM **534** would select a pre-provisioned virtual connection from mux **526** through ATM cross-connect **542** and ATM cross-connect **544** to mux **530**. CCM **534** would send an LAM message to CCM **538** through STP **520** and STP **522**. The LAM would indicate that a call was being routed to user **516** and would identify the selected virtual connection being used to reach mux **530**.

Typically, mux **530** would be connected to user **516** with a DS3 connection. CCM **538** would select a DS0 embedded in the DS3 and would send an IAM to user **516** through STP **522** and STP **524**. The CIC of the IAM would indicate that a call was being routed to user **516** over the selected DS0. User **516** would process the IAM and complete the call. When the call is answered, user **516** would transmit an answer message (ANM) through STP **524** back to system **500**.

CCM **534** would also send a UDP/IP message to mux **526** instructing it to assemble the user information in the DS0 from user **510** into ATM cells with a cell header identifying the selected virtual connection. CCM **538** would send a UDP/IP message to mux **530** instructing it to dis-assemble ATM cells from the selected virtual connection and output the user information to the selected DS0 to user **516**. ATM cross-connect **542** would route ATM cells from mux **526** to ATM cross-connect **544** based on the cell header. Likewise, ATM cross-connect **544** would route these cells to mux **530** based on the cell header. As such, user information for the call would flow from user **510** to user **516** over the DS0 from user **510**, the virtual connection selected by CCM **534**, and the DS0 to user **516** selected by CCM **538**. The muxes would implement the selections of the CCMs.

The call would require that a voice channel be available in both directions. As such, the DS0s and virtual connection would be bidirectional. Cut-through on the receive channel (from the user **516** to the user **510**) would occur after the address complete message (ACM) had been received by system **500**. Cut-through on the transmit channel (from the user **510** to the user **516**) would occur after the answer message (ANM) had been received by system **500**. This could be to accomplished by not allowing mux **530** to release any cells for the call until the ANM has been received by system **500**.

If user **510** were to place the call at night, CCM **534** would determine that user **514** was the destination. Accordingly a pre-provisioned virtual connection from mux **526** through ATM cross-connect **542** and ATM cross-connect **546** to mux **528** would be selected for the call. CCM **536** would select the DS0 to user **514**.

If user **510** were to place the call during the day, CCM **534** would determine that user **512** was the destination. Accordingly a pre-provisioned virtual connection from mux **526** through ATM cross-connect **542** and back to mux **526** would be selected for the call. CCM **534** would also select the DS0 to user **512**.

The Call/Connection Manager (CCM)

FIGS. **6–12** refer to a preferred embodiment of the signaling processor, also known as the CCM, but any processor which supports the requirements stated for the invention would suffice. FIG. **6** depicts a signaling processor suitable for the invention. Signaling processor **610** would typically be separate from the mux, but those skilled in the art appreciate that they could be housed together. Also, signaling processor may support a single mux or support multiple muxes.

Signaling processor **610** includes Message Transfer Part (MTP) level 1 **612**, MTP level 2 **615**, and MTP level 3 **620**.

MTP level 1 **612** defines the physical and electrical requirements for a signaling link. MTP level 2 **615** sits on top of level 1 and maintains reliable transport over a signaling link by monitoring status and performing error checks. Together, MTP levels 1–2 provide reliable transport over an individual link. A device would need MTP level 1–2 functionality for each link it uses. MTP level 3 **620** sits on top of level 2 and provides a routing and management function for the signaling system at large. MTP level 3 **620** directs messages to the proper signaling link (actually to the MTP level 2 for that link). MTP level 3 **620** directs messages to applications using the MTP levels for access the signaling system. MTP level 3 **620** also has a management function which monitors the status of the signaling system and can take appropriate measures to restore service through the system. MTP levels 1–3 correspond to layers 1–3 of the open systems interconnection basic reference model (OSIBRF). Both the MTP 1–3 and the OSIBRF are well known in the art.

Also shown for signaling processor **610** are ethernet interface **635**, platform handler **640**, message handler **645**, and data handler **650**. Ethernet interface **635** is a standard ethernet bus supporting TCP/IP which transfers signaling messages from MTP level 3 to platform handler **640**. Also, if UDP/IP is used to communicate with the muxes, ethernet interface **335** would accept the links to the muxes. Those skilled in the art will recognize other interfaces and protocols which could support these functions in accord with the invention.

In accord with this invention, the logic of the signaling interface (indicated by reference numerals **612**, **615**, **620**, and **635**) would be operational to route select ISUP messages to platform handler **640**. Technique for doing this have been discussed above. Preferably, an SS7 interface to platform handler **640** could be constructed using commercially available SS7 software interface tools. An example of such tools would be SS7 interface software provided by Trillium, Inc.

Platform handler **640** is a system which accepts ISUP and B-ISUP messages from ethernet interface **635** and routes them to message handler **645**. Preferably, platform handler **640** is configured to route messages to a particular message handler processor based on the signaling link selection (SLS) code in the message. Message handler **645** is a system which exchanges signaling with platform handler **640** and controls the connection and switching requirements for the calls. It can select and implement services and initiate echo control. It also converts signaling between ISUP and B-ISUP. Data handler **650** is a set of logic coupled to message handler **645** which processes service requests and provides data to message handler **645**. Data handler **650** also controls echo cancellers and generates billing records for the call.

In the discussions that follow, the term ISUP will include B-ISUP as well. In operation, ISUP messages that meet the proper criteria are routed by MTP and/or ATM interface **615**, MTP level 3 **620**, and ethernet interface **635** to platform handler **640**. Platform handler **640** would route the ISUP messages to message handler **645**. Message handler **645** would process the ISUP information. This might include validation, screening, and determining if additional data is needed for call processing. If so, data handler **650** would be invoked and would provide message handler **645** with the relevant data so message handler **645** could complete call processing. Message handler **645** would generate the appropriate ISUP message to implement the call and pass the signals to platform handler **640** for subsequent transmission to the designated network elements.

The distribution of functional entities among message handler **645** and data handler **650** are shown. These functional entities are well known in the art. Message handler **645** includes at least the call control function (CCF) and the service switching function (SSF). The CCF establishes and releases call connections, and the SSF recognizes triggers during call processing by the CCF and provides an interface between the CCF and the service control function (SCF). The SCF identifies services and obtains data for the service. In some embodiments, message handler **645** can include the SCF and the service data function (SDF). The SDF provides service data in real time to the SCF. Taken together, message handler **645** is able to at least control connections and recognize triggers. In some embodiments, message handler **645** can also identify services, obtain data for the services, and generate the signaling required to implement the services. Message handler **645** can provide signaling interworking (i.e. ISUP to B-ISUP), connection control, service selection and service implementation in a logically integrated package that interfaces with the network through conventional means.

Data handler **650** includes at least the SCF and the SDF. In some embodiments, message handler **645** and data handler **650** both include the SCF and the SDF and services are partitioned among the functional entities. Two other functions are shown in data handler that are not standardized functional entities. Accounting generates a billing record and echo handles the echo cancellers. Typically, an echo canceller is disabled for a data call and enabled after the data call for use on subsequent voice calls, however, other techniques are applicable.

In operation, the CCF would perform basic call processing until the SSF recognized a trigger and invoked the SCF. The SCF would identify the service associated with the trigger. The SCF would access data from the SDF in order to implement the service. The SCF would process the data from the SDF and provide the data to the CCF through the SSF. The CCF would then set-up the connections through conventional signaling to service switching points (SSPs). The SSPs are connected to the communications path and make the connections. Typically, an SSP is a switch. Also, echo cancellers may be controlled for the call, and a billing record could be generated for the call.

Those skilled in the art are aware of various hardware components which can support the requirements of the invention. For example, the platform handler, message handler, and data handler could each reside on a separate SPARC station **20**.

The Platform Handler

FIG. **7** shows a possible version of the platform handler. Platform handler **710** is shown. Platform handler **710** includes STP handler **712**, supervisor **714**, and CCM handler **716**. Platform handler **710** transmits and receives ISUP messages to/from the signaling interface (reference numerals **312**, **315**, **320**, and **335**). STP handler **712** would provide the ethernet—TCP/IP interface. STP handler **712** has a process to buffer and dis-assemble the incoming packets to the CCM, and buffer and assemble outgoing packets. STP handler **712** could also check the messages for basic flaws. Any technique for transfer of signaling messages to platform handler **710** is contemplated by the invention.

Supervisor **714** is responsible for managing and monitoring CCM activities. Among these are CCM start-up and shut-down, log-in and log-off of various CCM modules, handling administrative messages (i.e. error, warning, status,

etc.) from the CCM modules, and handling messages from network operations such as queries, configuration instructions, and data updates. The connection to network operations is the man machine interface which allows the CCM to be controlled and monitored by either a remote or a local operator. Supervisor **714** has a process which retrieves configuration data from internal tables to initialize and configure the CCM. The CCM modules also have internal tables which are used in conjunction with this procedure. Supervisor **714** also communicates internally with STP handler **712** and CCM handler **716**.

CCM handler **716** exchanges ISUP information with STP handler **712**. CCM handler **716** also exchanges ISUP messages and CCM supervisory messages with the message handler. The connection between CCM handler **716** and the message handler could be an ethernet LAN transporting these messages encapsulated in TCP/IP packets, but other methods are known. CCM handler **716** would provide the ethernet—TCP/IP interface. CCM handler **716** has a process to buffer and dis-assemble the incoming packets from the message handler, and buffer and assemble outgoing packets to the message handler. CCM handler **716** could also check the messages for basic flaws.

Internally, platform handler **710** is equipped with bi-directional channels which exchange information among STP handler **712**, supervisor **714**, and CCM handler **716**. The channels between STP handler **712**, CCM handler **715**, and supervisor **712** carry supervisory and administrative information. The channel between STP handler **712** and CCM handler **716** carries ISUP message information.

Platform handler **710** accepts, disassembles, and buffers ISUP messages received from the network. It can perform basic checks on the messages before transferring them to the message handler. Should more than one message handler be connected to platform handler **710**, the ISUP messages could be allocated to the message handlers based on the SLS of the particular ISUP message. CCM handler **716** accepts routing instructions from the message handler for routing certain ISUP messages to select processes of the message handler. Platform handler **710** also provides supervision and a man/machine interface for the CCM.

The Message Handler

FIG. **8** depicts a version of the message handler. Message handler **820** is shown and includes call center **821**, origination manager **822**, termination manager **823**, detection point manager **828**, feature manager **824**, auxiliary manager **825**, switching manager **826**, and local resource **827**. A primary function of message handler **820** is to process ISUP messages.

Call center **821** is the process which receives call set-up messages from the platform handler. ISUP call set-up is initiated with the IAM. When call center **821** receives an IAM, it creates an instance of an origination manager process with data defined by the information in the IAM. Origination manager **822** represents any of the origination manager processes spawned by call center **821**. The CCM handler is instructed of the new instance so that subsequent ISUP messages related to that call can be transferred directly to the appropriate instance of origination manager **822** by the platform handler.

Origination manager **822** sets up a memory block called an originating call control block. The call control block provides a repository for information specific to a call. For example, the originating call control block could identify the following: the call control block, the origination manager, the message handler, the originating LEC, the LEC trunk circuit (CIC), the ATM virtual circuit, the ATM virtual path, the caller's number, the dialed number, the translated dialed number, the originating line information, the ANI service class, the selected route, the number of the selected route, the SLS, the OPC, the DPC, the service indicator (SIO), echo cancellation status, reason of release, call status, and pointers to adjacent call control blocks. In addition, the call control block would also contain the various times that signaling messages are received, such the address complete message (ACM), the answer message (ANM), the suspend message (SUS), the resume message (RES), and the release message (REL). Those skilled in the art would be aware of other pertinent data to include.

Origination manager **822** executes call processing in accordance with the Basic Call State Model (BCSM) recommended by the International Telecommunications Union (ITU), but with some notable exceptions. Origination manager **822** processes the LAM through each point in call managers on a call by call basis. Service control center **931** notifies the Switching manager to route subsequent service request messages for that call to the appropriate service selection manager. Service selection manager **932** represents any of the service selection managers created by service control center **931**.

Service selection manager **932** executes the service portion of the call processing. Service selection manager **932** identifies the various services associated with each message and implements the service through messages to service logic center **933**. Service logic center **933** accepts messages from service selection **932** and creates instances of the feature processes required for the identified services. Examples of feature processes are N00, messaging, personal/terminal mobility, and virtual private network (VPN). Feature processes are service logic programs which implement the required services for a call. Feature process **934** represents any of the feature processes created by service logic center **933**. Feature process **934** accesses the network resources and data required to implement the service. This would entail executing service independent blocks (SIBs). A SIB is a set of functions. An example of a function would be to retrieve the called number from a signaling message. SEBs are combined to build a service. An example of a SEB is translating a called number.

Those skilled in the art are familiar with the above services, although they have never been implemented by a system such as the present invention. N00 services are services such as 800, 900, or 500 calling in which the dialed number is used to access call processing and billing logic defined by the subscriber to the service. Messaging entails connecting the caller to a voice messaging service. For example, the receipt of a release message (REL) with a cause of busy could be a trigger recognized by the message handler. In response, the data handler would create an instance of the messaging feature process and determined if a call placed to a particular dialed number would require the voice messaging platform. If so, the CCM would instruct an SSP to connect the caller to the voice message platform. Personal/Terminal mobility includes recognizing that the dialed number has mobility that requires a database look-up to determine the current number. The database is updated when the called party changes locations. VPN is a private dialing plan. It is used for calls from particular dedicated lines, from particular calling numbers (ANIs), or to particular dialed numbers. Calls are routed as defined for the particular plan. (PIC) until a detection point (DP) is encountered. When a detection point is encountered, a message is

sent to detection point manager **828** and processing is suspended at origination manager **822** until detection point manager **828** responds. An example of a detection point for origination manager **822** would be to authorize an origination attempt.

Detection point manager **828** accepts messages from originating manager **822** caused by a detection point encountered during call processing. Detection point manager **828** will identify whether or not the detection point is armed. An armed detection point has specific criteria which can affect call processing if met. If the detection point is not armed, detection point manager **828** will send a continue signal back to origination manager **822**. A continue message instructs origination manager **822** to continue call processing to the next detection point. If the detection point is armed, detection point manager **828** will take action to see if the detection point criteria are met. If detection point manager **828** requires assistance to process the armed detection point, it will send a message to feature manager **824**.

Feature manager **824** would accept messages from detection point manager **828** and either forward the a message to auxiliary manager **825** or to switching manager **826**. Particular feature messages would be routed to auxiliary manager **825** which will process these call features. These are typically non-IN features, such as echo control or POTS billing. Other feature messages would be routed to switching manager **826**. These are typically IN features. Examples of IN features are 800 number translation or a terminal mobility number translation. Feature manager **824** will pass information back to detection point manager **828** (then to origination manager **822**) when it is received back from auxiliary manager **825** or switching manager **826**.

Switching manager **826** which will determine if the request will be handled by local resource **827** or by the data handler. Local resource **827** will be structured to provide data more efficiently stored at message handler **820**. Examples of such data include: an automatic number identification (ANI) validation table which checks the caller's number, a dialed number translation table to translate POTS numbers into a routing instructions, or N00 translation tables to translate select 800 numbers into routing instructions. Examples of a routing instruction yielded by the tables would be a particular access connection or a virtual connection. An example of data in the data handler would be virtual private network (VPN) routing tables or complex 800 routing plans.

Typically, originating manager **822** will execute through the pertinent points in call to a point indicating that set up is authorized. At this point, origination manager **822** will instruct call center **821** to create an instance of a termination manager. Termination manager **823** represents any of these termination managers. Origination manager **822** will also transfer IAM information to termination manager **823**. Termination manager **823** sets up a memory block called a terminating call control block. The call control block provides a repository for information specific to a call and is similar in composition to the originating call control block.

Termination manager **823** also operates in accord with the BCSM of the flu, but also with some exceptions. Termination manager **823** continues processing for the call through its own points in call until detection points are encountered. When a detection point is encountered, a message is sent to detection point manager **828** and processing is suspended at termination manager **823** until detection point manager **828** responds. An example of detection point for termination manager **822** would be to authorize termination which would entail authorizing the call as set-up by origination manager **822**. Messages from termination manager **823** to detection point manager **828** are handled as discussed above for messages from originating manager **822**. When processing by termination manager **823** is complete, it will produce a signaling message to transmit through platform handler **410** to the appropriate multiplexers, and possibly to the users.

Message handler **820** communicates with the data handler using a data transfer protocol. Examples include UDP/IP, or the Intelligent Network Applications Protocol (INAP) which is contained within the component sublayer of Transaction Capabilities Application Part (TCAP).

The Data Handler

FIG. **9** shows a version of the data handler. Data handler **930** is shown. Data handler **930** includes service control center **931**, service selection **932**, service logic center **933**, feature process **934**, service data center **935**, service data manager **936**, echo control **937**, and accounting **938**. Data handler **930** receives service request messages from the message handler. These messages result from an armed detection points triggering the message handler to invoke data handler **930**. The messages also result from features implemented through the auxiliary manager. Service control center **931**, service logic center **933**, and service data center **935** are static processes created at start-up. Service control center **931** creates instances of service selection

In the execution of the SIB to provide the service, feature process **934** would invoke service data center **935** to create an instance of service data manager **936**. Service data manager **936** accesses the network databases that provide the data required for the service. Access could be facilitated by TCAP messaging to an SCP. Service data manager **936** represents any of the service managers created by service data center **935**. Once the data is retrieved, it is transferred back down to feature process **934** for further service implementation. When the feature processes for a call finish execution, service information is passed back down to the message handler and ultimately to the origination or termination manager for the call.

After a release message on a call, billing requests will be forwarded to accounting **938**. Accounting **938** will use the call control block to create a billing record. The call control block would contain information from the ISUP messages for the call and from CCM processing. From the address complete message (ACM), the call control block would include the routing label, CIC, message type, and cause indicators. From the answer message (ANM), the call control block would include the routing label, CIC, message type, and backward call indicators. From the initial address message (LAM), the call control block would include the routing label, CIC, message type, forward call indicators, user service information, called party number, calling party number, carrier identification, carrier selection information, charge number, generic to address, origination line information, original called number, and redirecting number. From the release message (REL), the call control block would include the routing label, CIC, message type, and cause indicators. From the suspend message (SUS) or the pass along message (PAM), the call control block would include the routing label, CIC, and message type. Those skilled in the art are familiar with other pertinent information for a billing record and appreciate that some of this information could be deleted.

For POTS calls, the billing request will come from the origination and termination managers through the auxiliary

manager. For IN calls, the request will come from service selection **932**. Accounting **938** will generate a billing record from the call control blocks. The billing record will be forwarded to a billing system over a billing interface. An example of such an interface is the I.E.E.E. 802.3 FTAM protocol.

At some point during call set-up, the origination manager, termination manager or even the detection point process will check the user service information data and originating line information to assess the need for echo control. If the call is a data call, a message is sent to data handler **930**. Specifically, the message is routed through the auxiliary manager to the echo control manager **937** in data handler **930**. Based on the CIC, echo control manager **937** can select which echo canceller and DS0 circuit needs to be disabled. A message will be generated to that effect and transmitted over a standard data link to the pertinent echo canceller or echo control system. As described above, echo control can be implemented by the multiplexer. Once a release (REL) message is received for the call, the echo canceller is re-enabled. On a typical call, this procedure will occur twice. Once for an echo canceller on the access side, and again for an echo canceller on the terminating side. The CCM that handles the IAM for a particular call segment will control the particular echo cancellers for the segment.

IAM Call Processing

Prior to a description of IAM processing, a brief description of SS7 message is given. SS7 messaging is well known in the art. SS7 ISUP messages contain numerous fields of information. Each message will have a routing label containing a destination point code (DPC), an origination point code (OPC), and a signaling link selection (SLS) which are used primarily for routing the message. Each message contains a circuit identification code (CIC) which its identifies the circuit to which the message relates. Each message contains the message type which is used to recognize the message. ISUP messages also contain mandatory parts filled with fixed length data and variable length data, in addition to a part available for optional data. These parts vary from message type to message type depending on the information needed.

The initial address message (IAM) initiates the call and contains call set-up information, such as the dialed number. LAMs are transferred in the calling direction to set up the call. During this process, TCAP messages may be sent to access remote data and processing. When the IAMs have reached the final network element, an address complete message (ACM) is sent in the backward direction to indicate that the required information is available and the called party can be alerted. If the called party answers, an answer message (ANM) is sent in the backward direction indicating that the call/connection will be used. If the calling party hangs up, a release message (REL) is sent to indicate the connection is not being used and can be torn down. If the called party hangs up, a suspend message (SUS) is sent and if the called party reconnects, a resume (RFS) message keeps the line open, but if their is no re-connection, a release message (REL) is sent. When the connections are free, release complete messages (RLC) are sent to indicate that the connection can be re-used for another call. Those skilled in the art are aware of other ISUP messages, however, these are the primary ones to be considered. As can be seen, the IAM is the message that sets-up the call.

In the preferred embodiment, call processing deviates from the basic call model recommended by the ITU, although strict adherence to the model could be achieved in other embodiments. FIGS. **10–12** depicts the preferred call processing. Referring first to FIG. **10**, When the IAM for a call is received at **1005**, the call center creates an instance of an origination manager at **1010**.

The origination manager begins call processing by sending an authorize message to the detection point manager. Detection point manager checks IAM information, including the dialed number, the CIC, and the originating line information, to perform service discrimination at **1015**. This is done to determine if the service requested requires validation at **1020**. Current call processing systems and the BCSM of the ITU both validate the call before performing service discrimination. In a significant advance over the prior art, the preferred embodiment deviates from known call processing methods by looking at the IAM information prior to validation to determine if validation is even required. For example, the calling party may not pay the bill for a call. The called party pays the bill on 800 calls and validation can be unnecessary. If validation is not required at **1020**, call processing proceeds directly to B. Advantageously, this avoids unnecessary look-ups in validation tables for a significant percentage of calls.

If validation is required at **1020**, a validation table is checked at **1025**. Validation checks to see if a call should be allowed and focuses on potential billing problems for the call. For example, calls from ANIs that are delinquent on payments pose problems for billing and may not be validated. Validation would entail messaging from the detection point manager through the feature manager and the switching manager to the local resource to access the tables. The table may list authorized ANIs, unauthorized ANIs, or both. If the call is not authorized at **1030**, treatment (i.e. route to an operator or message) is given to the call at **1035**.

If the call is authorized at **1030**, the services identified at **1015** are checked at **1040** to determine if the call can be routed. This would typically occur for POTS calls. If no additional services are required at **1040**, the dialed number is translated into a route instruction at **1045**. The route instruction could be a particular virtual connection and/or access connections. The processing then proceeds to A. If additional services are required at **1040**, processing proceeds to B.

FIG. **11** picks up processing at B after a route has been selected. A termination manager is created at **1105**. The termination manager is responsible for processing in accordance with the terminating BCSM of the ITU. However, in some embodiments, the processing can exhibit some deviation. For example, detection points such as select facility and validate call may be skipped.

The bearer capability is analyzed at **1110** to determine if the call is a data call at **1115**. This analysis could occur elsewhere in the call processing (i.e by the origination manager after the route is selected.) If a data call is found at **1115**, an echo control message is sent to the data handler at **1120**. Echo control instructions are created at **1125**. The echo control instructions identify the connection for the call which requires echo control. The message could be sent to the echo control system over a conventional data link from the CCM to the echo control system. If, the echo control is implemented in the multiplexers, the echo control message could be included with the route instruction message.

If the call is not a data call at **1115** or after echo control processing at **1125**, a signaling message is created at **1135**. The new signaling message identifies the access connections and virtual connection for the call. The new signaling

message can also contain echo control instructions. The new signaling message is sent to the platform handler at **1140**.

FIG. **12** picks up the processing at B. At this point, several things are known about the call concerning authorization and service requirements. The call information is then analyzed at **1205** as required to apply services to the call. If the data handler is not required at **1210**, the service is implemented and the route is selected at **1215**. This may occur if a service can be directly implemented by the origination manager or through the local resource. For example, particular 800 translations or dialed number service profiles (i.e call forwarding) can be stored in the local resource. In this case, route selection would be performed by the local resource after the information is analyzed to identify the correct entry to a local resource database. When the local resource is used, the messages must be routed from the detection point processor through the feature manager and switching manager to the local resource.

If the data handler is required for the call at **1210**, a message is sent to the data handler at **1220**. The messaging typically flows from the detection point processor to the feature manager and switching manager to the data handler. Upon receipt of the message at the data handler, the service control center creates an instance of the service selection process at **1225**. The service selection process analyzes the message from the detection point processor and selects the feature processes for the call at **1230**. For example, a call may be placed from a caller in a virtual private network (VPN) to a PCS number. In this case, both a VPN feature process and a PCS feature process would be created.

Each feature process would determine if data was required at **1240**. For example, a personal mobility feature process would need to access a database to locate the called party's current telephone number. If data is required at **1240**, the service data center creates a service data manager at **1245**. The data manager manages the data session and accesses the appropriate database at **1250**. After the data is collected (or none is needed), the service is implemented by the feature process at **1255**. For some features, i.e. 800 service, this may include route selection. The results of the feature process analysis are returned to the origination manager to assimilate. If the feature process does not provide the route, the origination manager must select the route using the local resource or another feature process.

The LAM itself contains numerous fields of information. The following table describes the elements of an IAM with regard to the information content and call processing.

TABLE 1

Initial Address Message

Parameter Field Name	Description
	ROUTING LABEL
Service Indicator	Set at 0101-ISDN user part
Priority	0 or 1 based on destination
Network ID	10 for national network or set based on international trunk group
Destination Point Code	Destination of IAM
Originating Point Code	Origination of IAM
Signaling Link Connection	Link used for messages (same for all messages for the call)
Circuit ID Code	Circuit used for the call between OPC and DPC in the IAM
Message Type	0000 or 0001 for IAM
	NATURE OF CONNECTION INDICATORS
Satellite Indicator	Increment for each satellite used
Continuity Check Indicator	00 -- no check 01 -- set up check and start COT timer 10 -- start timer for COT message.
Echo Suppresser Indicator	Indicates if echo control already implemented or is set if echo control is implemented
	FORWARD CALL INDICATORS
National/International Call Indicator	0 for domestic 1 for international
End to End Method Indicator	Pass any information
Interworking Indicator	Pass any information
IAM Segmentation Indicator	0 for POTS
ISDN User Part Indicator	Pass any information
ISDN Preference Indicator	Pass any information and default to 00
ISDN Access Indicator	Pass any information
SCCP Method Indicator	00
	CALLING PARTIES CATEGORY
Calling Party Category	00000000 for unknown 00001010 for ordinary caller 00001101 for test call
	USER SERVICE INFORMATION
Information Transfer Capability	Pass any information unless destination requires particular settings, but always pass ISDN "unrestricted digital information"

TABLE 1-continued

Parameter Field Name	Description
	Initial Address Message
Coding Standard	00
Extension	1
Information Transfer Rate	Pass any information (will be 10000 for POTS)
Transfer Mode	Set at 00 for 64 kbit/sec
Extension	1
User Layer Protocol Identification	Set based on rate adaption, typically 0100010 for user information layer 1
Extension	1 for normal calls 0 for rate adaption
Rate	Nothing for user information layer 1, but 0111 for other rate adaption
Extension	1
	CALLED PARTY NUMBER
Nature of Address Indicator	Identifies the type of call: 0000001 -- original NPA or 950 call 0000011 -- 1 + call 0000100 -- direct dial international call 1110001 -- operator call 1110010 -- operator default 1110011 -- international operator call 1110100 -- long distance operator call 1110101 -- cut through call 1110110 -- 950, hotel/motel, or non equal access call 1110111 -- test call
Odd/Even	number of digits in a called number
Numbering Plan	000 -- default 001 -- for ISDN 101 -- private
Digits Field	number of the called party
	ACCESS TRANSPORT
Access Transport Elements	pass any information
	CALLING PARTY NUMBER
Nature of Address Indicator	Indicates the type of calling party address, unique numbers can be used for billing, but the charge number is used for non-unique numbers: 0000000 -- unknown 0000001 -- unique caller number 0000011 -- unique national number 0000100 -- unique international number 1110001 -- non-unique caller number 1110011 -- non-unique national number 1110100 -- non-unique international number 1110111 -- test call
Odd/Even	Number of digits in the calling number
Screening	Not applicable
Presentation Allowed/Restricted	Pass any information for POTS, but restrict for N00 calls that are not allowed
Numbering Plan	000 -- default 001 -- ISDN 101 -- private
Digits Field	Number of the calling party
	CARRIER IDENTIFICATION
Network Identification Plan	Number of digits in identification code for the requested carrier
Type of Network Identification	Identifies the network numbering plan for the call -- 010 for POTS call from LEC
Digit One	First digit in carrier identification code
Digit Two	Second digit in carrier identification code
Digit Three	Third digit in carrier identification code
Digit Four or Null	Fourth digit in carrier identification code (if there are four digits)
	CARRIER SELECTION INFORMATION
Carrier Selection Indicator	Indicates whether the carrier identification code was presubscribed or input
	CHARGE NUMBER
Nature of Address Indicator	This information may be used for billing. 00000001 -- caller number

TABLE 1-continued

Parameter Field Name	Description
	Initial Address Message
	00000010 -- no ANI, route to operator 00000011 -- caller's national number 00000101 -- route if 800, or route to operator 0000110 -- no ANI 0000111 -- route if 800 or route to operator
Odd/Even	Number of digits in calling number
Numbering Plan	Pass any information
Digits Field	The number of calling party
	GENERIC ADDRESS
Nature of Address Indicator	Pass any information
Odd/Even	Pass any information
Screening	Pass any information
Presentation Allowed/Restricted	Pass any information
Numbering Plan	Pass any information
Digits Field	Pass any information
	ORIGINATING LINE INFORMATION
Originating Line Information	Identifies particular types of calls, for example: 00000000 -- normal call 00000111 -- call from a restricted phone 00111111 -- call from a cellular roamer
	ORIGINAL CALLED NUMBER
Nature of address Indicator	Pass any information
Odd/Even	Pass any information
Screening	Pass any information
Presentation Allowed/Restricted	Pass any information
Numbering Plan	Pass any information
Digits Field	Pass any information
	REDIRECTING NUMBER
Nature of Address Indicator	Pass any information
Odd/Even	Pass any information
Screening	Pass any information
Presentation Allowed/Restricted	Pass any information
Numbering Plan	Pass any information
Digits Field	Pass any information
	REDIRECTION INFORMATION
Redirection Indicator	Pass any information
Original Redirecting Reason	Pass any information
Redirection Counter	Pass any information
Redirection Reason	Pass any information
	SERVICE CODE
Service Code	Pass any information
	TRANSIT NETWORK SELECTION
Network Identification Plan	Identifies the number of digits in the carrier identification code (3 or 4)
Type of Network Identification	Type of network identification for transit network parameter
Digits 1,2,3,4	Carrier identification code of the international transit carrier
Circuit Code	Indicates how the call was dialed: 0001 -- international call, no operator requested 0010 -- international call, operator requested
	HOP COUNTER
Hop Counter	limits the number of times an IAM may transfer through a signaling point. If the count reaches the limit, release the call

Subsequent ISUP Message Processing

The processing of the IAM is discussed above. Those skilled in the art are will appreciate how other SS7 messages can be incorporated into the processing of the present invention. For example, the time an address complete message (ACM) is received is recorded in the call control block for billing and maintenance. Triggers can also be based on receipt of subsequent messages, such as the ACM. The process for the answer message (ANM) is much the same.

Cut-through is the time point at which the users are able to pass information along the call connection from end to end. Messages from the CCM to the appropriate network elements are required to allow for cut-through of the call. Typically, call connections include both a transmit path from

the caller and a receive path to the caller, and cut through is allowed on the receive path after the ACM is received and on the transmit path after the ANM is received.

Upon receipt of a release (REL) message, the CCM will write a time for the message to the call control block and check for triggers upon release (such as call re-originate). Additionally, any disabled echo canceller will be re-enabled, and the call control block will be used to create a billing record. Upon the receipt of a release complete message (RLC), the CCM will transmit messages directing tear down of the call path. It will clear its call specific processes and reuse the call connections for subsequent calls.

Additionally, suspend messages (SUS) and pass along messages (PAM) may be processed by the CCM. A suspend message (SUS) indicates that the called party has disconnected and a REL will follow if the called party does not re-connect with a specified time. A PAM is simply a message between signaling points and can contain a variety of information and be used for a variety of purposes.

The invention allows switching over an ATM fabric on a call by call basis. This allows efficient high capacity virtual connections to be exploited. Advantageously, the invention does not require signaling capability in an ATM switch. The invention does not require call processing capability in an ATM switch. This enables networks to implement ATM switching without these sophisticated ATM switches that support high volumes of calls. It also avoids the cost of these switches. The invention fully supports voice traffic and non-voice traffic. The invention supports services, such as N00, VPN, personal/terminal mobility, and voice messaging without requiring the service capability in an ATM switch. Relying on ATM cross-connects is advantageous because ATM cross-connects are farther advanced than ATM switches, and the cross-connects require less administrative support.

Those skilled in the art will appreciate that variations from the specific embodiments disclosed above are contemplated by the invention. The invention should not be restricted to the above embodiments, but should be measured by the following claims.

I claim:

1. A communication method comprising:

receiving information associated with a user communication into a processing system;

processing the information in the processing system to select an identifier;

generating a message containing the identifier;

transmitting the message from the processing system;

receiving the message into an interworking unit;

receiving the user communication into the interworking unit from a DS0 connection;

in the interworking unit, converting the user communication into an asynchronous communication with the identifier in a header in response to the message; and

transferring the asynchronous communication from the interworking unit.

2. The method of claim **1** further comprising receiving the asynchronous communication into a routing system and routing the asynchronous communication through the routing system based on the identifier in the header.

3. The method of claim **1** wherein receiving the information and the user communication comprises receiving a telecommunication call.

4. The method of claim **1** wherein the identifier is an asynchronous transfer mode connection.

5. The method of claim **1** wherein the processing system is external to telecommunication switches.

6. The method of claim **1** wherein receiving and processing the information to select the identifier comprises receiving and processing telecommunication signaling to select the identifier.

7. The method of claim **1** wherein receiving and processing the information to select the identifier comprises receiving and processing an initial address message to select the identifier.

8. The method of claim **1** wherein receiving and processing the information to select the identifier comprises receiving and processing a called number to select the identifier.

9. The method of claim **1** wherein processing the information in the processing system to select the identifier comprises accessing a service control point.

10. The method of claim **1** wherein processing the information in the processing system to select the identifier comprises validating a call.

11. The method of claim **1** wherein processing the information in the processing system to select the identifier comprises screening a call.

12. The method of claim **1** wherein processing the information in the processing system to select the identifier comprises routing a call.

13. The method of claim **1** wherein processing the information in the processing system to select the identifier comprises processing the information for an N00 service.

14. The method of claim **1** wherein processing the information in the processing system to select the identifier comprises processing the information for a mobility service.

15. The method of claim **1** wherein processing the information in the processing system to select the identifier comprises processing the information for a virtual network service.

16. The method of claim **1** wherein processing the information in the processing system to select the identifier comprises processing the information for a voice messaging service.

17. The method of claim **1** further comprising storing data for the user communication identifying an originating carrier, originating circuit, the identifier, caller number, called number, originating line information, and echo cancellation status.

18. The method of claim **1** further comprising storing data for the communication identifying receipt times for an answer message and a release message.

19. The method of claim **1** further comprising:

processing the information in the processing system to generate an echo cancellation instruction;

transmitting the echo cancellation instruction from the processing system;

receiving the echo cancellation instruction into the interworking unit; and

in the interworking unit, canceling echo from the user communication in response to the echo cancellation instruction.

20. The method of claim **1** further comprising:

processing the information in the processing system to an generate encryption instruction;

transmitting the encryption instruction from the processing system;

receiving the encryption instruction into the interworking unit; and

in the interworking unit, encrypting the user communication in response to the encryption instruction.

21. The method of claim **1** further comprising:

processing the information in the processing system to generate a compression instruction;

transmitting the compression instruction from the processing system;

receiving the compression instruction into the interworking unit; and

in the interworking unit, compressing the user communication in response to the compression instruction.

22. The method of claim **1** further comprising:

processing the information in the processing system to generate a decibel level instruction;

transmitting the decibel level instruction from the processing system;

receiving the decibel level instruction into the interworking unit; and

in the interworking unit, adjusting a decibel level of the user communication in response to the decibel level instruction.

23. A communication system comprising:

a processing system configured to receive information related to a user communication, process the information to select an identifier, generate a message containing the identifier, and transmit the message; and

an interworking unit configured to receive the message, receive the user communication from a DS0 connection, convert the user communication into an asynchronous communication with the identifier in a header in response to the message, and transfer the asynchronous communication.

24. The system of claim **23** further comprising a routing system configured to receive the asynchronous communication and route the asynchronous communication based on the identifier in the header.

25. The system of claim **23** wherein the information and the user communication comprises a telecommunication call.

26. The system of claim **23** wherein the identifier is an asynchronous transfer mode connection.

27. The system of claim **23** wherein the processing system is external to telecommunication switches.

28. The system of claim **23** wherein the information comprises telecommunication signaling.

29. The system of claim **23** wherein the information comprises an initial address message.

30. The system of claim **23** wherein the processing system is configured to process a called number in the information to select the identifier.

31. The system of claim **23** wherein the processing system is configured to access a service control point to select the identifier.

32. The system of claim **23** wherein the processing system is configured to process the information to validate a call.

33. The system of claim **23** wherein the processing system is configured to process the information to screen a call.

34. The system of claim **23** wherein the processing system is configured to process the information to route a call.

35. The system of claim **23** wherein the processing system is configured to process the information for an N00 service.

36. The system of claim **23** wherein the processing system is configured to process the information for a mobility service.

37. The system of claim **23** wherein the processing system is configured to process the information for a virtual network service.

38. The system of claim **23** wherein the processing system is configured to process the information for a voice messaging service.

39. The system of claim **23** wherein the processing system is configured to store data for the communication identifying an originating carrier, originating circuit, the identifier, caller number, called number, originating line information, and echo cancellation status.

40. The system of claim **23** wherein the processing system is configured to store data for the communication identifying receipt times for an answer message and a release message.

41. The system of claim **23** wherein:

the processing system is configured to process the information to generate and transmit an echo cancellation instruction; and

the interworking unit is configured to receive the echo cancellation instruction and cancel echo from the user communication in response to the echo cancellation instruction.

42. The system of claim **23** wherein:

the processing system is configured to process the information to generate and transmit an encryption instruction; and

the interworking unit is configured to receive the encryption instruction and encrypt the user communication in response to the encryption instruction.

43. The system of claim **23** wherein:

the processing system is configured to process the information to generate and transmit a compression instruction; and

the interworking unit is configured to receive the compression instruction and compress the user communication in response to the compression instruction.

44. The system of claim **23** wherein:

the processing system is configured to process the information to generate and transmit a decibel level instruction; and

the interworking unit is configured to receive the decibel level instruction and adjust a decibel level in the user communication in response to the decibel level instruction.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,473,429 B1
DATED : October 29, 2002
INVENTOR(S) : Joseph Michael Christie

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Title page,
Item [63], **Related U.S. Application Data**, replace "Continuation of application No. 08/525,897, filed on Sep. 8, 1995, now Pat. No. 5,991,301, which is a continuation-in-part of application No. 08/568,551, filed on Dec. 7, 1995, now Pat. No. 5,825,780, which is a continuation of application No. 08/238,505, filed on May 5, 1994, now abandoned." with -- Continuation of application No. 08/525,897, filed on Sep. 8, 1995, now Pat. No. 5,991,301, which is a continuation-in-part of application No. 08/238,605, filed on May 5, 1994, now abandoned. --

Signed and Sealed this

Twenty-seventh Day of January, 2004

Jon W. Dudas

JON W. DUDAS
Acting Director of the United States Patent and Trademark Office

UNITED STATES PATENT AND TRADEMARK OFFICE

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Signed and Sealed this

Fifteenth Day of February, 2005

JON W. DUDAS
Director of the United States Patent and Trademark Office

EXHIBIT F

US006298064B1

(12) **United States Patent**
Christie

(10) **Patent No.: US 6,298,064 B1**
(45) **Date of Patent: Oct. 2, 2001**

(54) **BROADBAND TELECOMMUNICATIONS SYSTEM**

(75) Inventor: **Joseph Michael Christie**, San Bruno, CA (US)

(73) Assignee: **Sprint Communications Company, L. P.**, Kansas City, MO (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **09/504,408**

(22) Filed: **Feb. 15, 2000**

Related U.S. Application Data

(63) Continuation of application No. 09/353,401, filed on Jul. 15, 1999, which is a continuation of application No. 08/525,897, filed on Sep. 8, 1995, now Pat. No. 5,991,301, which is a continuation-in-part of application No. 08/568,551, filed on Dec. 7, 1995, now Pat. No. 5,825,780, which is a continuation of application No. 08/238,605, filed on May 5, 1994, now abandoned.

(51) **Int. Cl.**[7] **H04L 12/56**; H04L 12/28

(52) **U.S. Cl.** **370/410**; 370/466

(58) **Field of Search** 370/385, 386, 370/389, 395, 396, 397, 398, 399, 409, 410, 422, 426, 466, 467, 465; 379/229, 230, 231

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,453,247	6/1984	Suzuki et al. .
4,720,850	1/1988	Oberlander et al. .
4,763,317	8/1988	Lehman et al. .

(List continued on next page.)

OTHER PUBLICATIONS

McDysan, David E. and Spohn, Darren L., ATM Theory And Application, 1994, p. 256: 9.3.1; ATM Layer VPI/VCI Level Addressing.

"Revised Draft Of Q.2650 (DSS2/B–ISUP Interworking Recommendation)," Study Group 11, Geneva, ITU—Telecommunication Standardization Sector, Nov. 29–Dec. 17, 1993.

"Draft Broadband/Narrowband NNI Networking Recommendation," Study Group 11, Geneva, ITU—Telecommunication Standardization Sector, Dec. 1993.

Yoshikai, N., et al., "General Arrangements for Interworking Between B–ISDN and 63kbit/s Based ISDN (Draft Recommendation I.580), Study Group 13," ITU–T Telecommunication Standardization Sector, pp. 1–51, (Mar. 7, 1994).

"Interworking B–ISUP and Q.93B for DDI, MSN, TP and SUB", Study Group 11, Temporary Document 2/II–31I, ITU–Telecommunication Standardization Sector, Nov. 29–Dec. 17, 1993.

Minoli, Daniel/DVI Communications, Inc./Stevens Institute of Technology and Dobrowski, George/Bell Communications Research (Bellcore), Principles Of Signaling For Cell Relay And Frame Relay © pp. 1–2, 5–6 and 229, 1994.

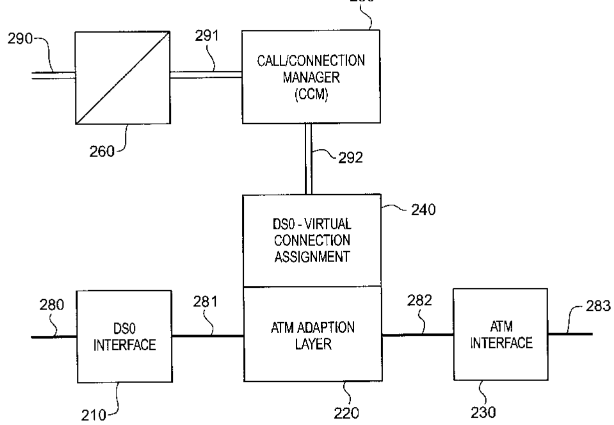
(List continued on next page.)

Primary Examiner—Ajit Patel
(74) *Attorney, Agent, or Firm*—Harley R. Ball; Steven J. Funk

(57) **ABSTRACT**

The invention is a system for providing virtual connections through an ATM interworking multiplexer on a call-by-call basis. A signaling processor receives signaling for a call and selects the virtual connection for the call. The signaling processor generates new signaling that identifies the selection and transfers the new signaling to the ATM interworking multiplexer that accepted the access connection for the call. The multiplexer converts user information from the access connection into ATM cells for transmission over the virtual connection in accord with the new signaling.

68 Claims, 12 Drawing Sheets



U.S. PATENT DOCUMENTS

4,926,416		5/1990	Weik .	
5,051,983		9/1991	Kammerl .	
5,115,431		5/1992	Williams et al. .	
5,168,492		12/1992	Beshai et al. .	
5,204,857		4/1993	Obara .	
5,233,607		8/1993	Barwig et al. .	
5,274,680		12/1993	Sorton et al. .	
5,327,421		7/1994	Hiller et al. .	
5,339,318		8/1994	Tanaka et al. .	
5,345,445		9/1994	Hiller et al. .	
5,345,446		9/1994	Hiller et al. .	
5,365,524		11/1994	Hiller et al. .	
5,392,402		2/1995	Robrock, II .	
5,414,701		5/1995	Shtayer et al. .	
5,420,858		5/1995	Marshall et al. .	
5,422,882		6/1995	Hiller et al. .	
5,426,636		6/1995	Hiller et al. .	
5,428,607		6/1995	Hiller et al. .	
5,428,609		6/1995	Eng et al. .	
5,434,852		7/1995	La Porta et al. .	
5,452,296		9/1995	Shimizu .	
5,452,297		9/1995	Hiller et al. .	
5,459,722		10/1995	Sherif .	
5,473,679	*	12/1995	La Porta et al.	370/410
5,479,402		12/1995	Hata et al. .	
5,483,527	*	1/1996	Doshi et al.	370/410
5,509,010		4/1996	LaPorta et al. .	
5,530,724		6/1996	Adrams et al. .	
5,570,368		10/1996	Murakami et al. .	
5,577,039		11/1996	Won et al. .	
5,623,491		4/1997	Skoog .	
5,623,493		4/1997	Kagemoto .	
5,673,262		9/1997	Shimizu .	
5,684,792		11/1997	Ishihara .	
5,771,234		6/1998	Wu et al. .	
5,787,086		7/1998	McClure et al. .	
5,805,568		9/1998	Shinbashi .	
5,825,780		10/1998	Christie .	
5,926,482		7/1999	Christie .	
5,991,301		11/1999	Christie .	
6,014,378		1/2000	Christie et al. .	
6,016,319	*	1/2000	Kshirsagar et al.	370/410
6,016,343		1/2000	Hogan et al. .	
6,023,474		2/2000	Gardner .	
6,064,648	*	5/2000	Hellman et al.	370/410
6,067,299		5/2000	DuRee .	
6,081,529		6/2000	Christie .	
6,115,380		9/2000	Christie et al. .	
6,172,977		1/2001	Christie et al. .	

OTHER PUBLICATIONS

McKinney, Scott, "ATM for Narrowband Services" 2460 IEEE Communications Magazine, Apr., 1994, New York, US, pp. 64–72.

Kuribayashi, Shin–Ichi, "Advanced Signaling Protocol for Broadband Services" Electronics and Communications in Japan, Part 1, vol. 78 No. 1, 1995, January, New York, US, pp. 1–12.

ITU–TQ. 1208, General Aspects of the Intelligent Network Application Protocol, ITU–T Recommendation Q.1208.

ITU–T Q.1218 Addendum 1, Series Q: Switching and Signalling Intelligent Network, Interface Recommendation for Intelligent Network CS–1, Addendum 1: Definition for two new contexts in the SDF data model.

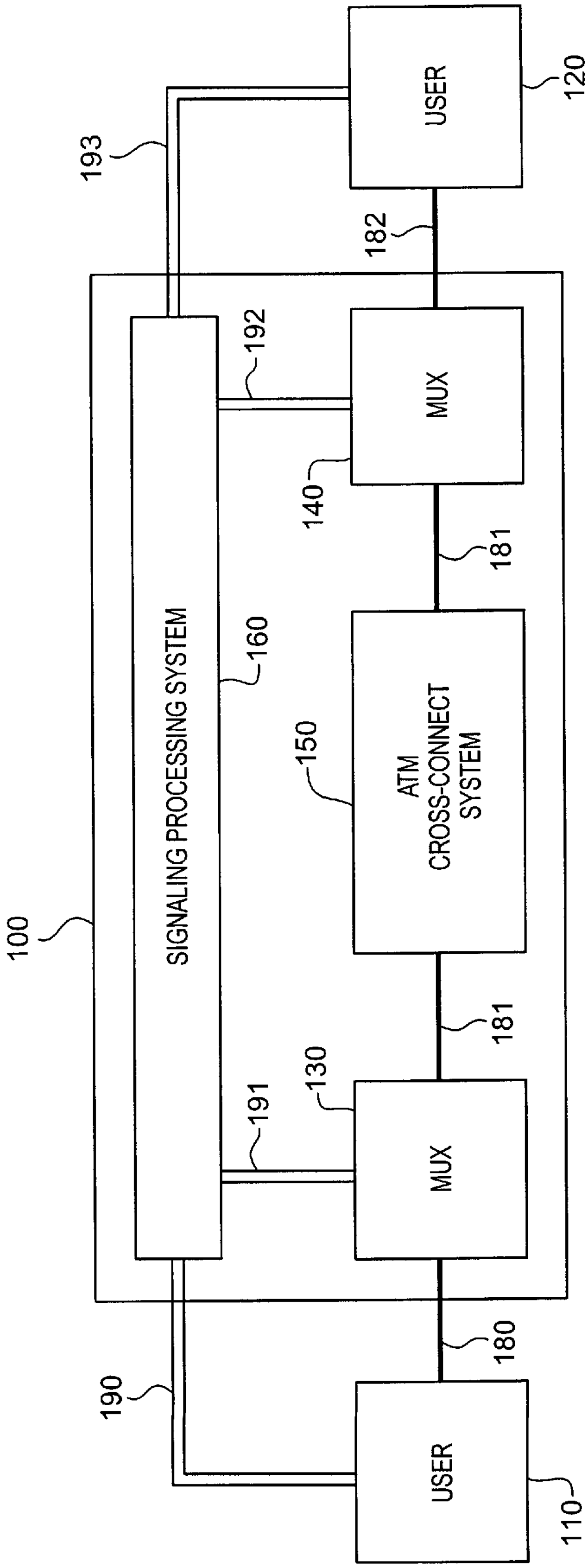
Tanabe, Shirou, et al., "A New Distributed Switching System Architecture for B–ISDN," International Conference on Integrated Broadband Services and Networks, Oct. 15–18, 1990. The Institution of Electrical Engineers, Savory Place, London.

Palmer, Rob, et al., "An Experimental ATM Network Featuring De–Coupled Modular Control," IEEE Region 10 Conference, TENCON, Nov. 1992.

ITU–T Recommendation I.121 (Arp., 1991) Broadband Aspects of ISDN.

ITU–T Recommendation H.200 (Mar., 1993) Framework for Recommendations for Audiovisual Services.

* cited by examiner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MUX
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USER
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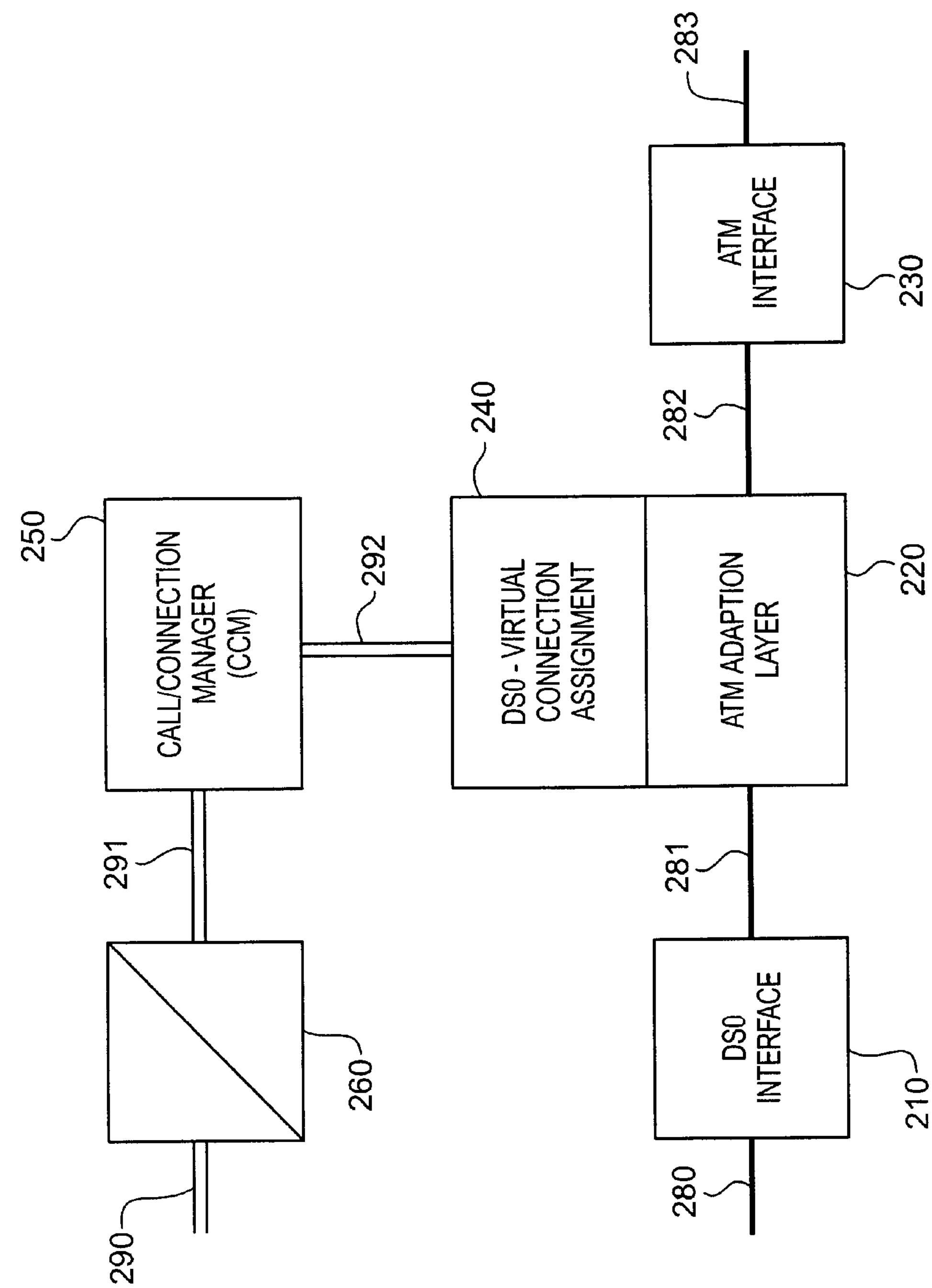
FIG. 1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ATM ADAPTION LAYER
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DS0 INTERFACE
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FIG. 2

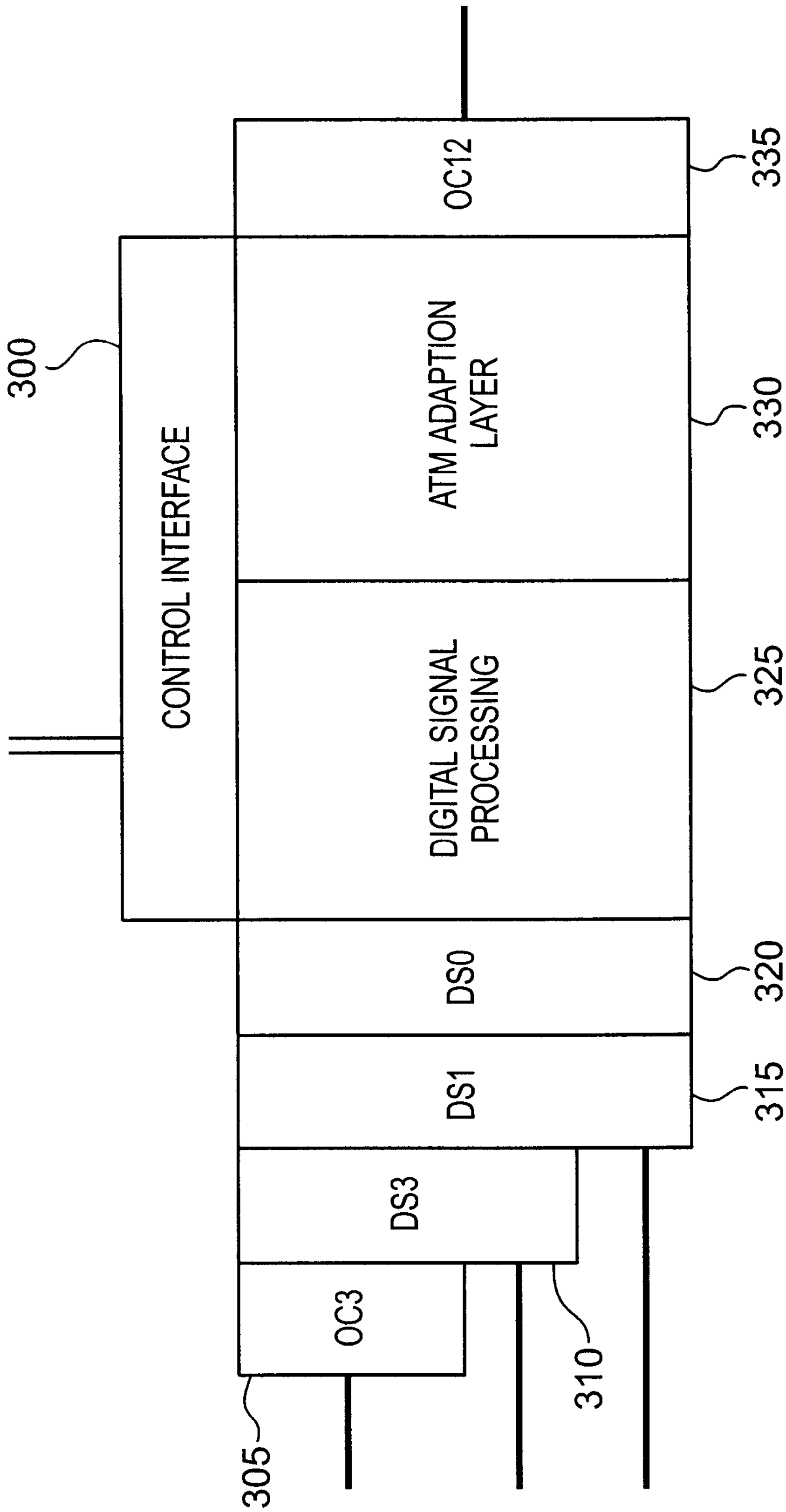
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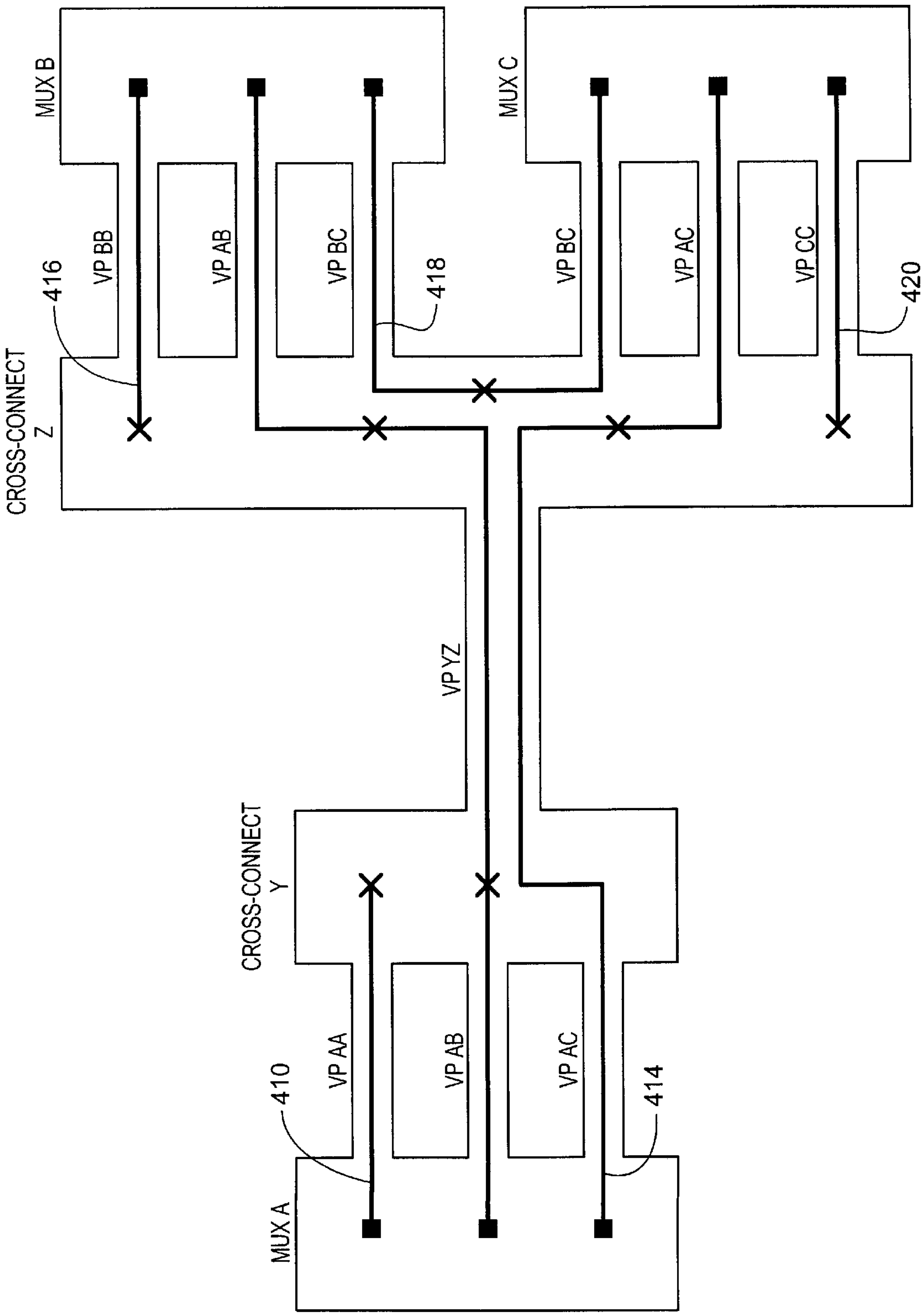
FIG. 3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VP AB
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VP AA
VP AB
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414
MUX A

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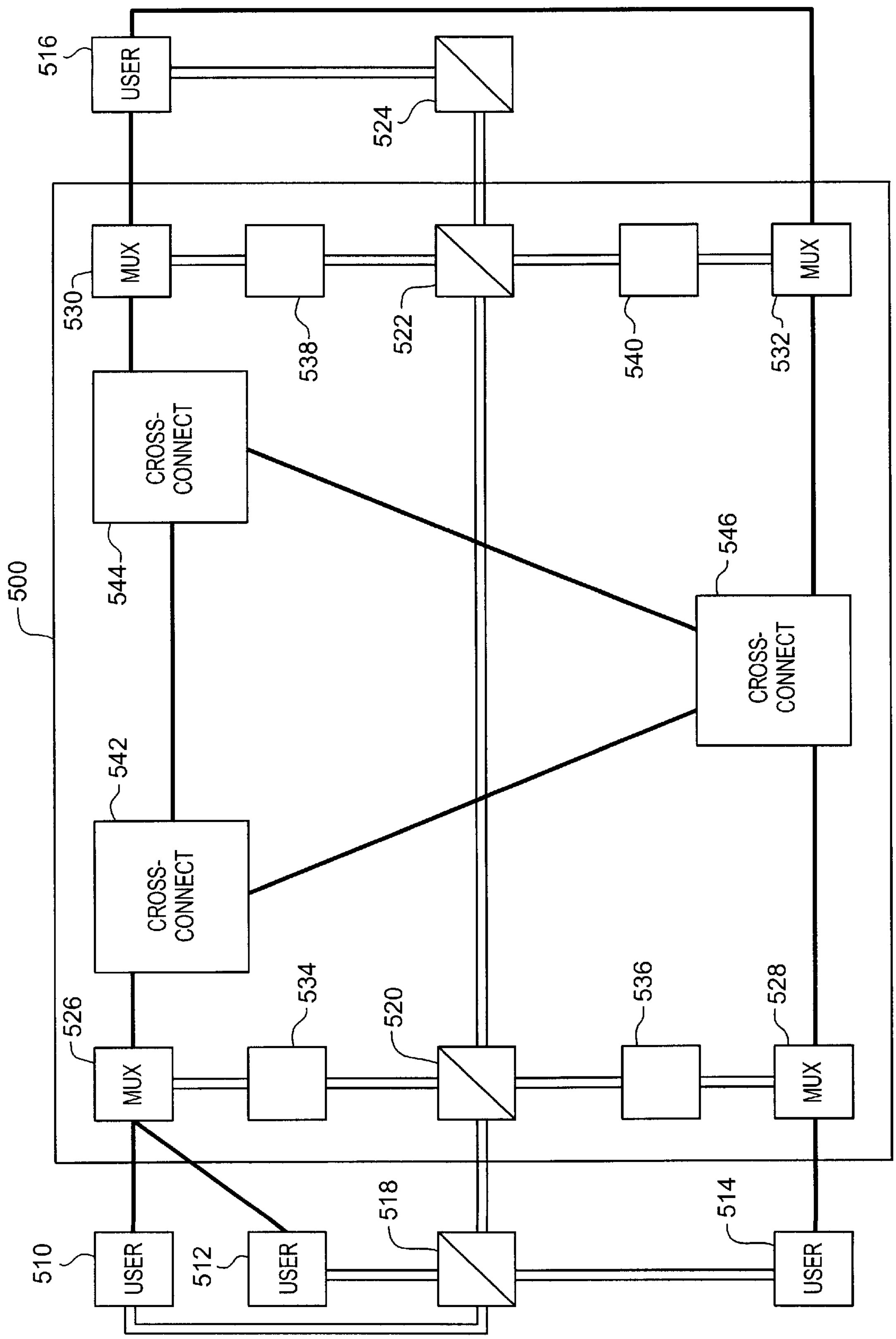

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USER
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USER
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USER
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MUX
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MUX
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CROSS-CONNECT
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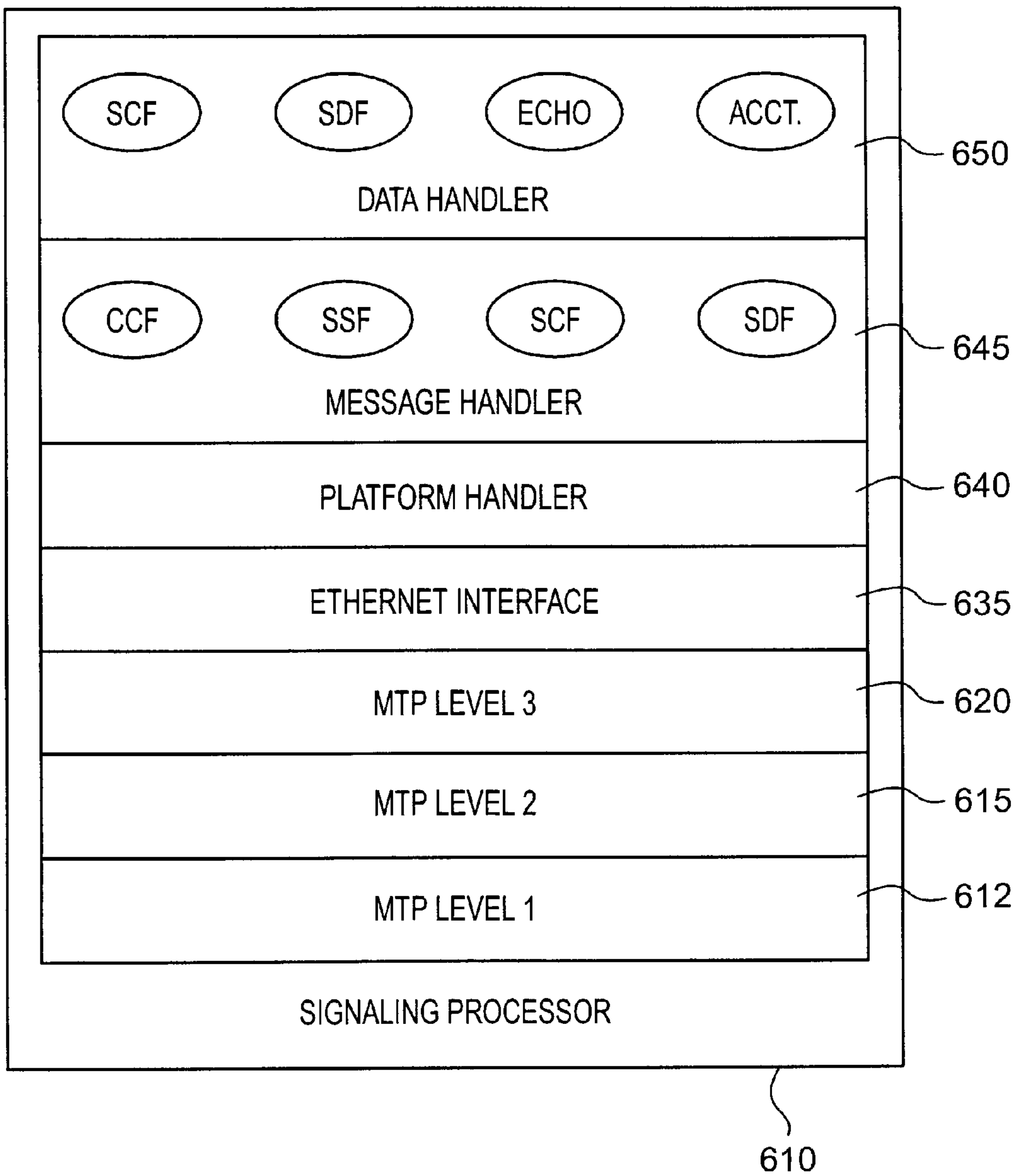
CROSS-CONNECT
546
CROSS-CONNECT

FIG. 5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MTP LEVEL 2
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MTP LEVEL 1
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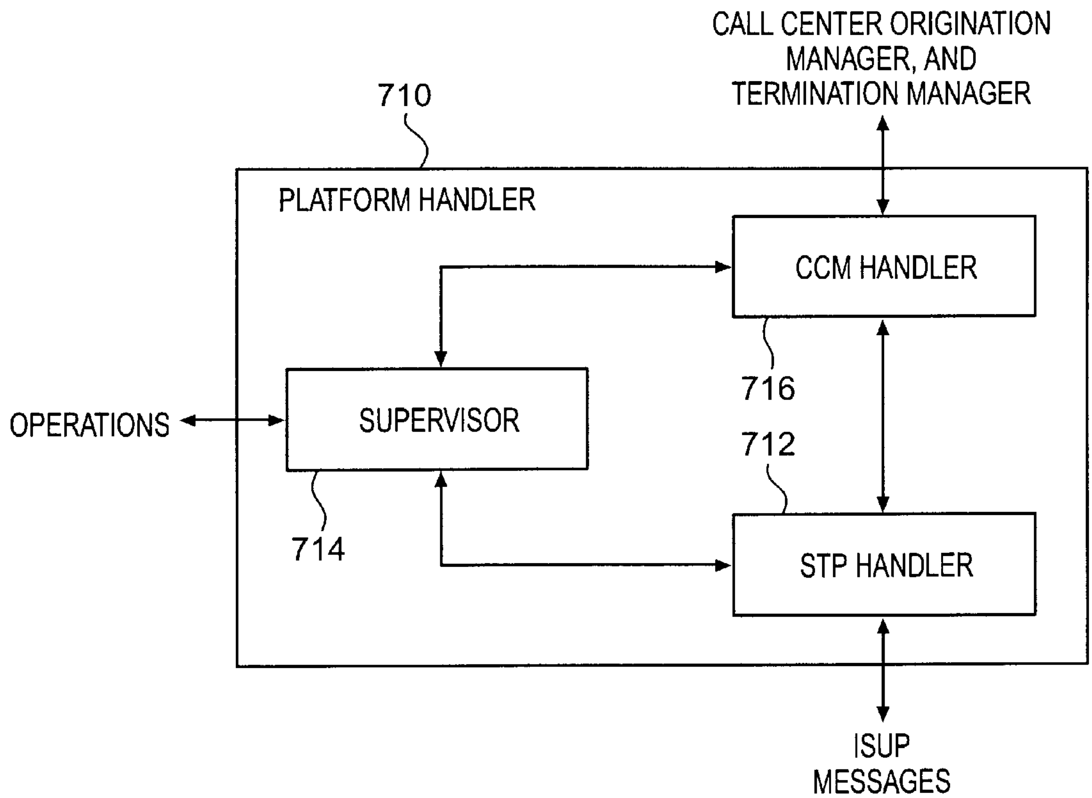
SIGNALING PROCESSOR
610

FIG. 6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CCM HANDLER
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OPERATIONS
SUPERVISOR
712
714
STP HANDLER
ISUP MESSAGES

FIG. 7

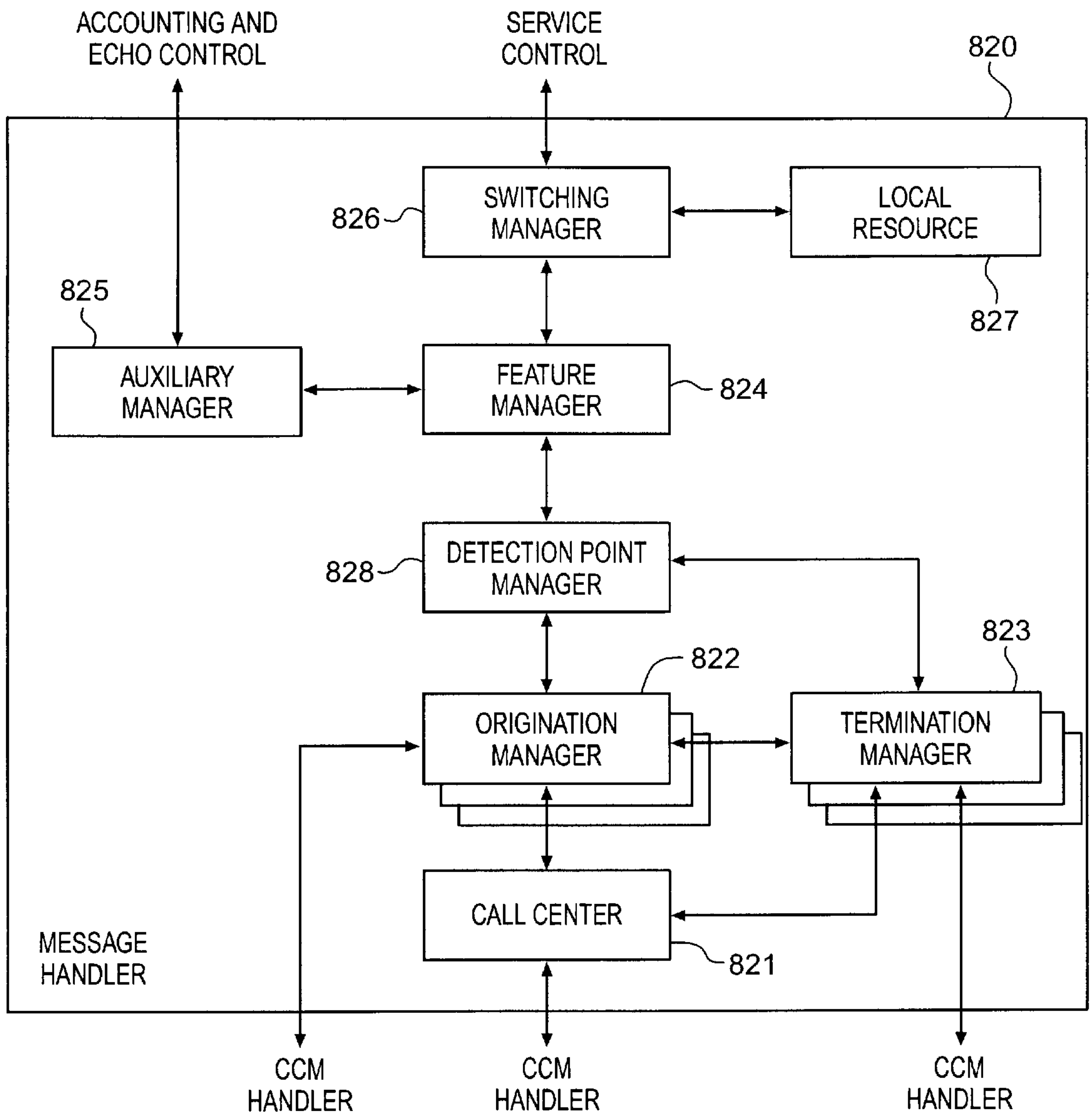
ACCOUNTING AND ECHO CONTROL
SERVICE CONTROL
820
SWITCHING MANAGER
826
LOCAL RESOURCE
827
825
AUXILIARY MANAGER
FEATURE MANAGER
824
DETECTION POINT MANAGER
828
822
823
ORIGINATION MANAGER
TERMINATION MANAGER
CALL CENTER
821
MESSAGE HANDLER
CCM HANDLER
CCM HANDLER
CCM HANDLER

FIG. 8

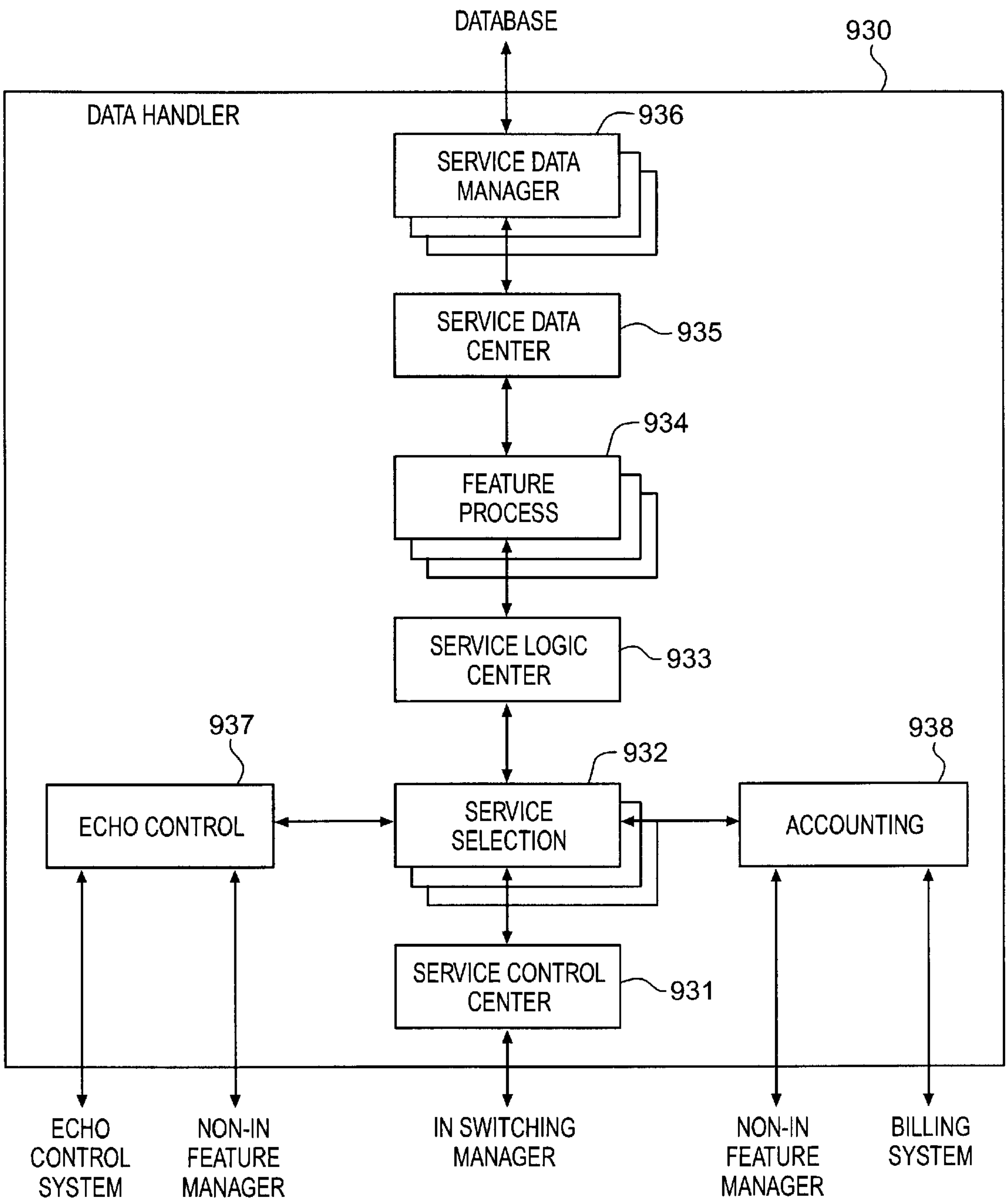
DATABASE
930
DATA HANDLER
936
SERVICE DATA MANAGER
SERVICE DATA CENTER
935
934
FEATURE PROCESS
SERVICE LOGIC CENTER
933
937
938
932
ECHO CONTROL
SERVICE SELECTION
ACCOUNTING
SERVICE CONTROL CENTER
931
ECHO CONTROL SYSTEM
NON-IN FEATURE MANAGER
IN SWITCHING MANAGER
NON-IN FEATURE MANAGER
BILLING SYSTEM

FIG. 9

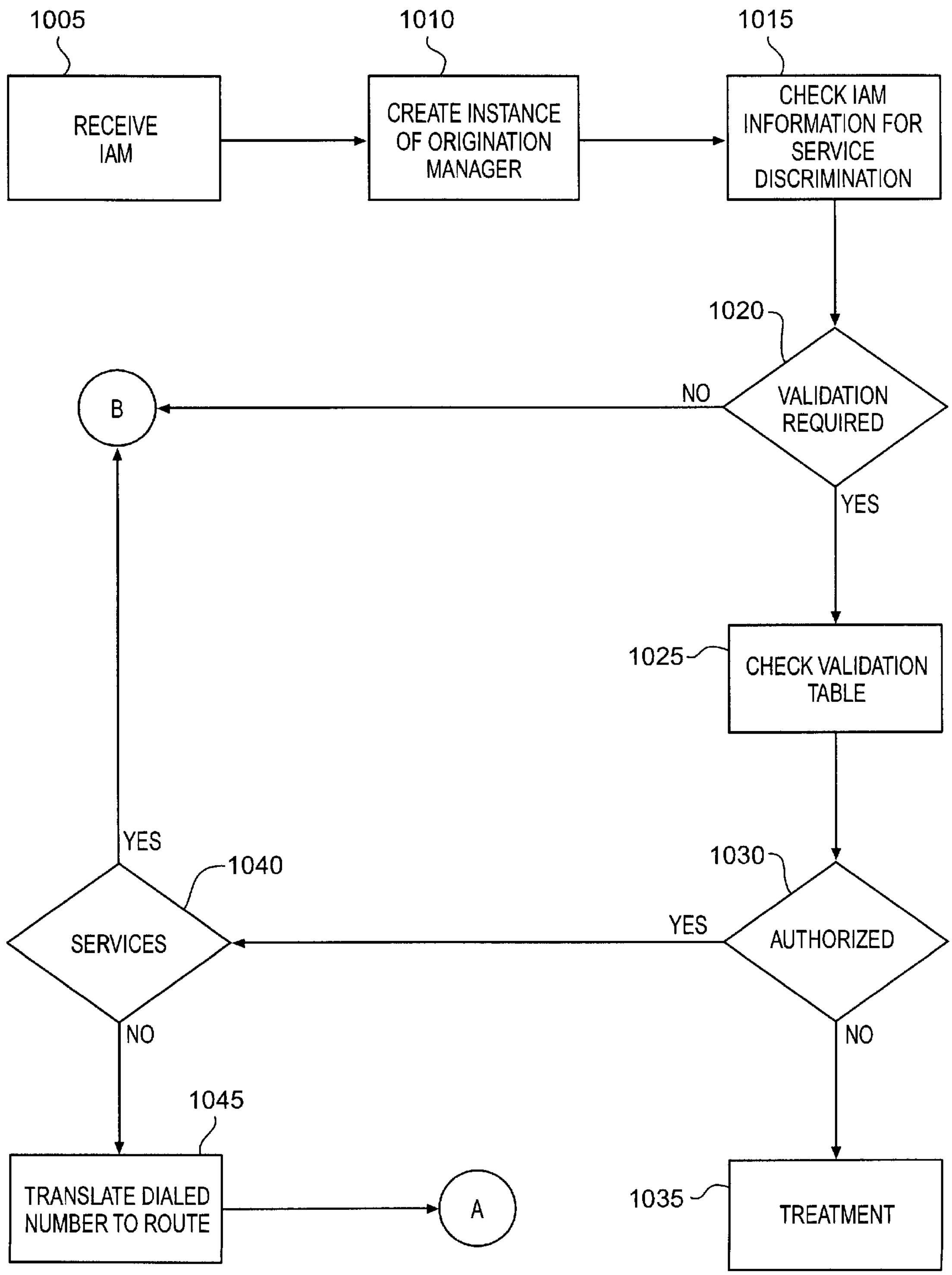
1005
RECEIVE IAM
1010
CREATE INSTANCE OF ORIGINATION MANAGER
1015
CHECK IAM INFORMATION FOR SERVICE DISCRIMINATION
1020
VALIDATION REQUIRED
NO
B
YES
1025
CHECK VALIDATION TABLE
1030
AUTHORIZED
YES
NO
1040
SERVICES
YES
NO
1045
TRANSLATE DIALED NUMBER TO ROUTE
A
1035
TREATMENT

FIG. 10

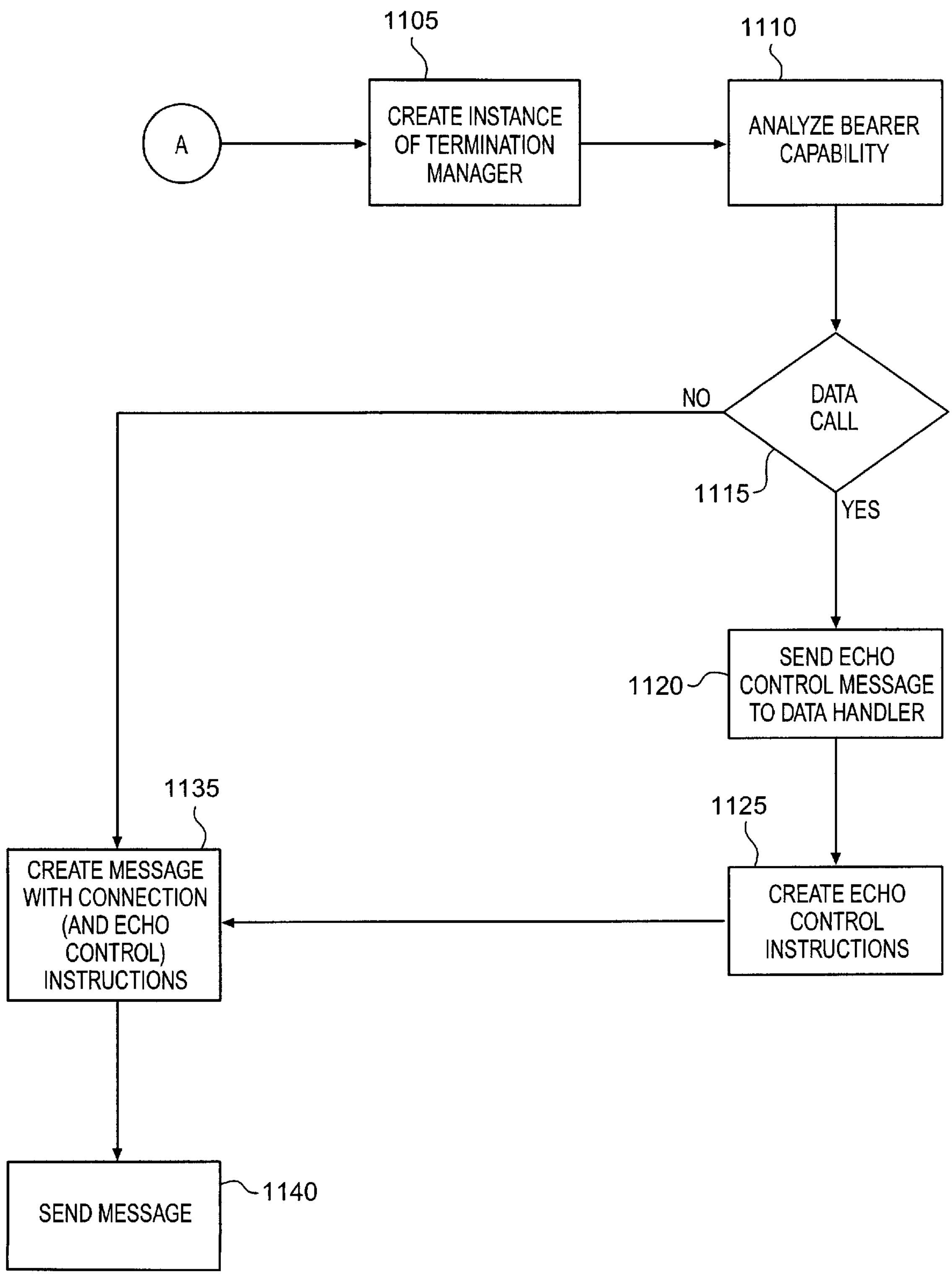
1105
1110
A
CREATE INSTANCE OF TERMINATION MANAGER
ANALYZE BEARER CAPABILITY
NO
DATA CALL
1115
YES
1120
SEND ECHO CONTROL MESSAGE TO DATA HANDLER
1135
1125
CREATE MESSAGE WITH CONNECTION (AND ECHO CONTROL) INSTRUCTIONS
CREATE ECHO CONTROL INSTRUCTIONS
SEND MESSAGE
1140

FIG. 11

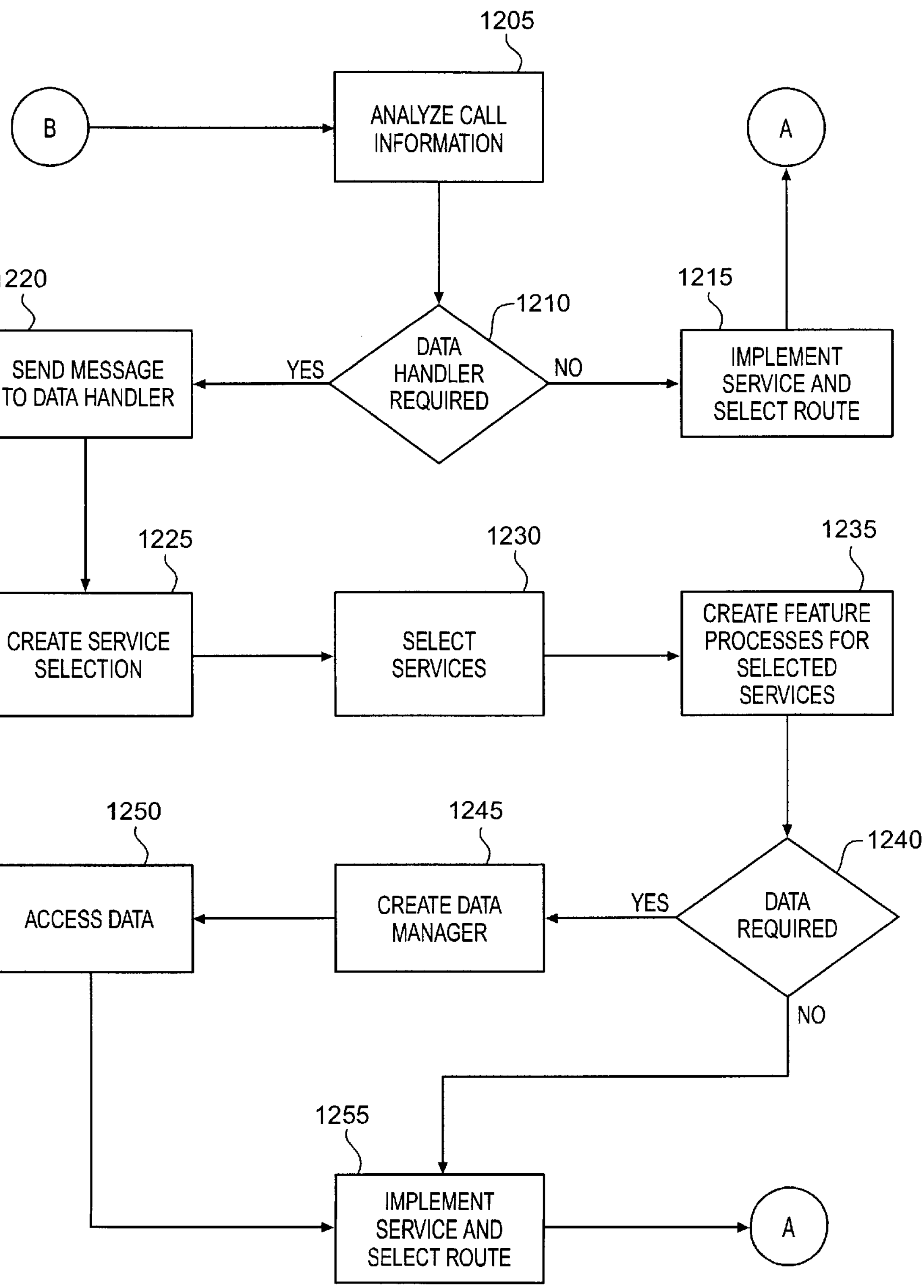
1205
B
ANALYZE CALL INFORMATION
A
1220
1215
1210
SEND MESSAGE TO DATA HANDLER
YES
DATA HANDLER REQUIRED
NO
IMPLEMENT SERVICE AND SELECT ROUTE
1225
1230
1235
CREATE SERVICE SELECTION
SELECT SERVICES
CREATE FEATURE PROCESSES FOR SELECTED SERVICES
1250
1245
1240
ACCESS DATA
CREATE DATA MANAGER
YES
DATA REQUIRED
NO
1255
IMPLEMENT SERVICE AND SELECT ROUTE
A

FIG. 12

BROADBAND TELECOMMUNICATIONS SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 09/353,401, entitled "BROADBAND TELECOMMUNICATIONS SYSTEM", filed Jul. 15, 1999, which is incorporated by reference into this application and which is a continuation of U.S. patent application Ser. No. 08/525,897, filed on Sep. 8, 1995, which is incorporated by reference into this application, and which is a continuation-in-part of U.S. Pat. No. 08/568,551, filed Dec. 7, 1995, now U.S. Pat. entitled "METHOD, SYSTEM, AND APPARATUS FOR TELECOMMUNICATIONS CONTROL", which is incorporated by reference into this application, and which is a continuation of U.S. patent application Ser. No. 08/238,605, filed May 5, 1994, now abandoned, which is incorprated by reference into this application.

BACKGROUND

At present, Asynchronous Transfer Mode (ATM) technology is being developed to provide broadband switching capability. Some ATM systems have used ATM cross-connects to provide virtual connections. Cross-connect devices do not have the capacity to process signaling. Signaling refers to messages that are used by telecommunications networks to set-up and tear down calls. Thus, ATM cross-connects cannot make connections on a call by call basis. As a result, connections through cross-connect systems must be pre-provisioned. They provide a relatively rigid switching fabric. Due to this limitation, ATM cross-connect systems have been primarily used to provide dedicated connections, such as permanent virtual circuits (PVCs) and permanent virtual paths (PVPs). But, they do not to provide ATM switching on a call by call basis as required to provide switched virtual circuits (SVCs) or switched virtual paths (SVPs). Those skilled in the art are well aware of the efficiencies created by using SVPs and SVCs as opposed to PVCs and PVPs. SVCs and SVPs utilize bandwidth more efficiently.

ATM switches have also been used to provide PVCs and PVPs. Since PVCs and PVPs are not established on a call-by-call basis, the ATM switch does need to use its call processing or signaling capacity. ATM switches require both signaling capability and call processing capability to provide SVCs and SVPs. In order to achieve virtual connection switching on a call by call basis, ATM switches are being developed that can process calls in response to signaling to provide virtual connections for each call. These systems cause problems because they must be very sophisticated to support current networks. These ATM switches must process high volumes of calls and transition legacy services from existing networks. An example would be an ATM switch that can handle large numbers of POTS, **800**, and VPN calls. This generation of sophisticated ATM switches is not yet mature and should be expensive when they are first deployed.

Currently, ATM multiplexers are being developed that can interwork traffic into ATM cells and multiplex the cells for transport over an ATM network. One example of an application of these muxes is provided by T1 transport over an ATM connection. Traffic that leaves the switch in T1 format is muxed into ATM cells for transport over a high speed connection. Before the cells reach another switch, they are converted back into the T1 format. Thus, the ATM mux is

used for high speed transport. The ATM mux is not used to select virtual connections on a call-by-call basis. Unfortunately, there is not a telecommunications system that can provide ATM switching on a call by call basis without relying on the call processing and signaling capability of an ATM switch.

SUMMARY

The invention includes a method of operating a telecommunications system to provide a call with a virtual connection. The method is for use when a user places the call by sending signaling for the call to the telecommunications system and by transmitting user information to the telecommunications system over a particular connection. The system comprises an ATM interworking multiplexer and a signaling processor linked to the ATM interworking multiplexer. The method comprises receiving the signaling for the call into the signaling processor, processing the signaling to select the virtual connection, generating new signaling to identify the particular connection and the selected virtual connection, and then transmitting the new signaling to the ATM interworking multiplexer. The method also includes receiving the user information for the call from the particular connection into the ATM interworking multiplexer, converting the user information into ATM cells that identify the selected virtual connection in response to the new signaling, and transmitting the ATM cells over the selected virtual connection. The signaling for the call could be a call set-up message, such a Signaling System **#7** (**SS7**) initial address message (IAM). The method could also include applying digital signal processing (DSP) to the call in the multiplexer in accord with DSP requirements selected by the signaling processor. DSP requirements could include echo control or encryption.

The invention also includes a telecommunications system to provide a call with a virtual connection in response to signaling for the call. The system comprises a signaling processor to receive and process signaling to select the virtual connection for the call, and to generate and transmit new signaling that identifies the selected virtual connection. The system includes an ATM interworking multiplexer to receive user information from a connection, convert the user information into ATM cells that identify the selected virtual connection, and transmit the ATM cells over the selected virtual connection. The system could also include an ATM cross-connect system connected to the ATM interworking multiplexer and configured to provide a plurality of virtual connections to the ATM interworking multiplexer.

The invention also includes an ATM interworking multiplexer for providing calls with virtual connections in response to signaling for each of the calls. The multiplexer comprises an access interface to receive user information for each call from a particular connection. It also includes a control interface to receive signaling for each call that identifies the particular connection and a virtual connection for that call. It also includes an ATM adaption processor to convert user information from the particular connection for each call into ATM cells that identify the virtual connection for that call. The multiplexer also includes an ATM interface to transmit the ATM cells for each call over the virtual connection. The multiplexer could include a digital signal processor to apply digital signal processing to the user information for each call. The processing could include echo control and encryption.

In various embodiments, the invention accepts calls placed over DS**0** voice connections and provides virtual

connections for the calls. In this way, broadband virtual connections can be provided to narrowband traffic on a call-by-call basis without requiring the call processing and signaling capability of an ATM switch.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of a version of the present invention.

FIG. **2** is a block diagram of a version of the present invention.

FIG. **3** is a block diagram of a version of the present invention.

FIG. **4** is a block diagram of a version of the present invention.

FIG. **5** is a block diagram of a version of the present invention.

FIG. **6** depicts a logic diagram of a version of the invention.

FIG. **7** depicts a logic diagram of a version of the invention.

FIG. **8** depicts a logic diagram of a version of the invention.

FIG. **9** depicts a logic diagram of a version of the invention.

FIG. **10** depicts a flow diagram of a version of the invention.

FIG. **11** depicts a flow diagram of a version of the invention.

FIG. **12** depicts a flow diagram of a version of the invention.

DETAILED DESCRIPTION

For purposes of clarity, the term "connection" will be used to refer to the transmission media used to carry user traffic. The term "link" will be used to refer to the transmission media used to carry signaling. On the Figures, connections are shown by a single line and signaling links are shown by double lines.

FIG. **1** depicts a version of the present invention. Shown is telecommunications system **100**, user **110**, and user **120**. Telecommunications system **100** includes ATM interworking multiplexer (mux) **130**, mux **140**, ATM cross-connect system **150**, and signaling processing system **160**. User **110** is connected to mux **130** by connection **180**. Mux **130** and mux **140** are connected through cross-connect system **150** by connection **181**. Mux **140** is connected to user **120** by connection **182**. Signaling processing system **160** is linked to user **110** by link **190**, to mux **130** by link **191**, to mux **140** by link **192**, and to user **120** by link **193**.

Those skilled in the art are aware that large networks have many more components than are shown. For example, there would typically be a multitude of virtual connections through ATM cross-connect system **150**. The number of these components has been restricted for clarity. The invention is fully applicable to a large network.

User **110** and user **120** could be any entity that supplies telecommunications traffic to network **100**. Some examples would be a local exchange carrier (LEC) switch or customer premises equipment (CPE). Typically, the user traffic would be provided to system **100** in DS3, DS1, or OC-**3** format that have embedded DS0 and VT 1.5 circuits. Connections **180** and **182** represent any connection that might be used by user **120** to access system **100** and would also include formats such as E1, E3, and DS2. As such, these connections are periodically referred to as access connections. Connections **180** and **182** would typically be DS0 connections embedded within a DS3 connection, however, the invention fully contemplates other connection being used with a few examples being a fractional DS1, a clear DS3, or even SONET OC-**3**. Links **190** and **193** are any links capable of transferring signaling messages with an example being Signaling System #7 (SS7) links. ATM cross-connect system **150** is any system that provides a plurality of virtual connections. Such a system could be comprised of individual ATM cross-connect devices interconnected by ATM connections using DS3 or SONET for transport. An example of an ATM cross-connect is the NEC Model **10**. Connection **181** could be any virtual connection. Typically, the virtual connection would use DS3 or SONET for transport. ATM cross-connect system **150** would be pre-provisioned to provide a plurality of virtual connections through the cross-connect system, and virtual connection **181** represents one of these connections. As virtual connections are logical paths, many physical paths can be used based on the pre-provisioning of ATM cross-connect system **150**. Links **191** and **192** could be any links capable of transporting data messages. Examples of such links could be SS7 or UDP/IP. The components described in this paragraph are known in the art.

Signaling processing system **160** is any processing platform that can receive and process signaling to select virtual connections, and then generate and transmit signaling to identify the selections. Various forms of signaling are contemplated by the invention, including SS7, C7, and user to network interface (UNI) signaling. A preferred embodiment of the signaling processor is discussed in detail toward the end of the disclosure.

Mux **130** could be any muxing system operable to place user information arriving over connection **180** on the virtual connection selected by signaling processing system **160**. Typically, this involves receiving signaling messages from signaling processing system **160** that identify assignments of virtual connections to an access connection on a call by call basis. The mux would convert user traffic from access connection **180** into ATM cells that identify the selected virtual connection. Mux **140** is similar to mux **130**. A preferred embodiment of these muxes are also discussed in detail below.

The system would operate as follows for a call from user **110** to user **120**. User **110** would send a signaling message over link **190** to system **100** initiating the call. Signaling processing system **160** would process the message. Such processing could include validation, screening, translating, route selection, echo control, network management, signaling, and billing. In particular, a virtual connection through ATM cross-connect system **150** from mux **130** to mux **140** would be selected, and a connection from mux **140** to user **120** would also be selected. Although many possible connections would be available, only the selected connections are shown—connection **181** and connection **182**. Generally, the selection is based on the dialed number, but call processing can entail many other factors with a few examples being network loads and user routing instructions. Signaling processing system **160** would then send signaling reflecting the selections to mux **130** and mux **140**.

User **110** would also seize a connection to system **100**. The connection is represented by connection **180** to mux **130**. Although, only one connection is shown for purposes of clarity, numerous connections would typically be available for seizure. The seized connection would be identified in the signaling from user **110** to system **100**. Signaling processing

system **160** would include the identity of this connection in its signal to mux **130**.

If required, user **120** would receive signaling to facilitate completion of the call. The signaling from signaling processing system **160** would indicate that system **100** was connecting to user **120** over connection **182**. Typically, user **120** would accept and acknowledge the connection in a signaling message back to system **100**.

Mux **130** would receive signaling from signaling processing system **160** identifying connection **180** as the access connection and connection **181** as the selected virtual connection through ATM cross-connect system **150**. Mux **130** would convert the user information from connection **180** into ATM cells. Mux **130** would designate connection **181** in the cell headers. Connection **181** would have been previously provisioned through ATM cross-connect system **150** from mux **130** to mux **140**.

Mux **140** would receive signaling from signaling processing system **160** identifying connection **181** as the selected virtual connection and connection **182** as the selected access connection to user **120**. Mux **140** would convert cells arriving on connection **181** to user information suitable for connection **182** to user **120**. Although the above example employs two muxes, a single mux could be employed for calls that enter and exit system **100** through the same mux. In this case, the ATM system would simply provide a virtual connection back to the same mux.

From the above discussion, it can be seen that multiple virtual connections can be pre-provisioned through an ATM cross-connect system to interconnect ATM interworking multiplexers. When a user places a call, one of the virtual connections is selected for the call by the signal processing system and identified to the appropriate muxes. The muxes convert the user information into cells that identify the selected connection. As such, user information can be switched through an ATM fabric on a call by call basis. The system does not require the call processing or signaling capabilities of an ATM switch (although an ATM switch could be used to provide the virtual connections without using its call processing and signaling functions). The system can also implement enhanced services such as N**00** and virtual private network (VPN).

FIG. **2** depicts another embodiment of the invention. In this embodiment, the user information from the access connection is capable of being muxed to the DS**0** level, but this is not required in other embodiments. Additionally, SS**7** signaling is used in this embodiment, but other signaling protocols, such as C**7** or UNI signaling, are also applicable to the invention.

Shown are DS**0** interface **210**, ATM adaption layer (AAL) **220**, ATM interface **230**, DS**0**—virtual connection assignment **240**, call/connection manager (CCM) **250** and signal transfer point (STP) **260**. Also shown are connections **280–283** and links **290–292**.

Connection **280** could by any connection or group of connections that contain information that can be converted to DS**0** format. Examples of these connections are OC-**3**, VT**1.5**, DS**3**, and DS**1**. DS**0** interface **210** is operable to convert user information in these formats into the DS**0** format. AAL **220** comprises both a convergence sublayer and a segmentation and reassembly (SAR) layer. AAL **220** is operational to accept the user information in DS**0** format from DS**0** interface **210** and convert the information into ATM cells. AALs are known in the art and information about AALs is provided by International Telecommunications Union (ITU) document I.**363.1**. An AAL for voice is also described in patent application Ser. No. 08/395,745, filed on Feb. 28, 1995, entitled "Cell Processing for Voice Transmission", and hereby incorporated by reference into this application. ATM interface **230** is operational to accept ATM cells and transmit them over connection **283**. Connection **283** is a standard DS**3** or SONET connection transporting ATM cells. Connection **281** is operational for the DS**0** format and connection **282** is operational to transfer ATM cells.

It can be seen that a communications path through connections **280–283** could be established to carry user information. Although the communications path has been described from connection **280** to connection **283**, the invention contemplates components that are also operational to perform reciprocal processing in the reverse direction. If the communications path is bi-directional, user information in ATM cells arriving on connection **283** would be processed for output on connection **280** in the appropriate format. Those skilled in the art will appreciate that separate connections could also be set up in each direction, or that only a connection in one direction may be required. These components and their operation are known in the art.

Signaling links **290** and **291** are SS**7** links. Link **292** is a data link with an example being an ethernet connection transporting UDP/IP. STP **260** is device that routes signaling messages. STPs are well known in the art. CCM **250** would be identified by its own signaling point code. STP **260** would route signaling messages addressed to this point code to CCM **250**. In some embodiments, STP **260** may also convert other point codes to the point code for CCM **250** so these signaling messages are also routed to CCM **250**. Although point code conversion is not essential, it facilitates the transition of a network to the system of the invention. The conversion could be implemented through a conversion table located between level **2** and level **3** of the message transfer part (MTP) function of STP **260**. The conversion table would convert the destination point code of the message to that of CCM **250**, so that the route function of MTP **3** would forward the message to CCM **250**. Point code conversion could be based on many factors with a few examples being the destination point code, the origination point code, the signaling link, the circuit identification code, the message type, and various combinations of these and other factors. For example, SS**7** Integrated Services User Part (ISLUP) messages with particular OPC/DPC combinations could have the DPC converted to the point code of CCM **250**. These signaling messages would then be routed to CCM **250** by STP **260**. One version of a suitable STP is disclosed in U.S. patent application entitled "Telecommunications Apparatus, System, and Method with Enhanced Signal Transfer Point", filed simultaneously with this application, assigned to the same entity, and hereby incorporated by reference into this application.

CCM **250** is a signaling processor that operates as discussed above. A preferred embodiment of CCM **250** is provided later. In this embodiment CCM **250** would be operable to receive and process SS**7** signaling to select connections, and to generate and transmit signaling identifying the selections.

Assignment **240** is a control interface that accepts messages from CCM **250**. In particular, assignment **240** identifies DSO/virtual connection assignments in the messages from link **292**. These assignments are provided to AAL **220** for implementation. As such, AAL **220** obtains the virtual path identifier (VPI) and virtual channel identifier (VCI) for each call from assignment **240**. AAL **220** also obtains the identity of the DS**0** for each call (or the DSOs for an N×64

call). AAL **220** then converts user information between the identified DS**0** and the identified ATM virtual connection. Acknowledgments that the assignments have been implemented may be sent back to CCM **250** if desired.

In operation, calls are processed as follows. Signaling messages for calls arrive on link **290** and are routed by STP **260** to CCM **250**. Access connections are typically seized contemporaneously with the signaling. All of these connections are represented by connection **280**. DS**0** interface **210** would convert the traffic on connection **280** into the DS**0** format and provide the DSOs to AAL **220** over connection **281**.

The signaling received by CCM **250** would identify the access connections for the calls (i.e. the particular DSOs on connection **280**), and contain call information, such as a dialed number. CCM **250** would process the signaling and select connections for the call. Since multiple virtual connections are pre-provisioned from ATM interface **230** to the other destinations in the network, CCM **250** can select a virtual connection to the destination. The selection process can be accomplished through table look-ups. For example, a table could be used to translate a portion of the dialed number into a VPI. The VCI would be selected based on the available VCIs in the selected VPI. The VPI/VCI combination would correspond to a unique virtual connection pre-provisioned from ATM interface **230** to the appropriate network destination. The selections represent the DS**0**—virtual connection assignments that are provided to assignment **240** over link **292**.

Assignment **240** accepts the DS**0**—virtual connection assignments and provides them to AAL **220**. When AAL **220** receives a particular assignment, it converts user information from the designated DS**0** into cells that identify the designated VPI/VCI. The cells are provided to ATM interface **230** over connection **282**. ATM interface **230** accepts the cells and places them within the transport format for connection **283**. The cells are then transported over the selected virtual connection to the appropriate destination.

Calls also exit the network through connection **280**. In this case, CCMs at the origination points select the virtual connections to ATM interface **230**. The originating CCMs also send signaling messages to CCM **250**. The signaling messages identify the destinations for the calls and the selected virtual connections. CCM **250** will have a list of available access connections to the identified destinations. CCM **250** will select the access connections to the destination from the list. For example, the connection selected by CCM **250** could be a DS**0** embedded within a DS**3** connected to a LEC. The virtual connections on connection **283** and selected access connections on connection **280** are provided to assignment **240** over link **292**. Assignment **240** provides these assignments to AAL **220**.

ATM interface **230** will demux the cells arriving from connection **283** and provide them to AAL **220**. AAL **220** converts the user information in the cells into the DS**0** format. AAL **220** make the conversion so that cells from a particular virtual connection are provided to the assigned DS**0** on connection **281**. DS**0** interface will convert the DSOs from connection **281** into the appropriate format, such as DS3, for connection **280**. Those skilled in the art are aware of the techniques for muxing and transporting DS**0** signals.

From the above discussion, it can be seen that user information for calls can flow from connection **280** to connection **283**, and in the reverse direction from connection **283** to connection **280**. DS**0** interface **210** and ATM interface **230** provide user information in their respective formats to AAL **220**. AAL **220** converts the user information between DS**0** and ATM formats based on the assignments from assignment **240**. CCM **250** can select the DSO—virtual connection assignments that drive the process.

The ATM Interworking Multiplexer

FIG. **3** shows one embodiment of the mux that is suitable for the present invention, but muxes that support the requirements of the invention are also applicable. Shown are control interface **300**, OC-**3** interface **305**, DS**3** interface **310**, DS**1** interface **315**, DS**0** interface **320**, digital signal processing(DSP) **325**, AAL **330**, and OC-**12** interface **335**.

OC-**3** interface **305** accepts the OC-**3** format and makes the conversion to DS**3**. DS**3** interface **310** accepts the DS**3** format and makes the conversion to DS**1**. DS**3** interface **310** can accept DS3s from OC-**3** interface **305** or from an external connection. DS**1** interface **315** accepts the DS**1** format and makes the conversion to DSO. DS**1** interface **315** can accept DSls from DS**3** interface **310** or from an external connection. DS**0** interface **320** accepts the DS**0** format and provides an interface to digital signal processing (DSP) **325**.

DS**0** interface **320** is coupled to DSP **325**. DSP **325** is capable of manipulating the user information to improve transmission quality. DSP processing primarily entails echo cancellation, but could include other features as well. As is known, echo cancellation can be required for voice calls. DSP **325** passes the DSOs through echo cancellers. These echo cancellers must be disabled for calls that do not require echo control. Data calls do not require echo cancellation, and the CCM has the ability to recognize data calls that require an echo canceller to be disabled. The CCM will send a control message through control interface **300** to DSP **325** indicating the particular echo canceller that is to be disabled. The CCM selects the echo canceller based on the CIC in the signaling it receives from the user. After the data call, the CCM sends a message that causes the particular echo canceller to be enabled again for subsequent voice calls. The above technique of applying echo control is preferred, but other means of implementing echo control instructions from the CCM are also applicable.

In addition to echo control, the CCM and the mux can work to provide other digital signal processing features on a call by call basis. Compression algorithms can be applied, either universally, or on a per call basis. The decibel level could be adjusted for calls form a particular origin or to a particular destination, i.e. where a hearing impaired person may reside. Encryption could be applied on a call-by-call basis based on various criteria like the origination number or the destination number. Various DSP features could be associated with various call parameters and implemented by the CCM through DSP **325**.

DSP **325** is connected to AAL **330**. AAL **330** operates as described above for an AAL. DSO—virtual connection assignments from control interface **300** are implemented by AAL **330** when converting between the DS**0** and ATM formats.

Calls with a bit rate greater than 64 kbit/sec. are known as Nx64 calls. If desired, AAL **330** can be capable of accepting control messages through control interface **300** from the CCM for N×64 calls. The CCM would instruct AAL **330** to group the DSOs for the call.

The ATM Cross-connect System

FIG. **4** depicts virtual connections provided by the ATM cross connect system in a version of the invention, although

numerous other techniques for providing virtual connections will be appreciated by one skilled in the art, and the invention contemplates any such system. Shown are virtual connections **410, 412, 414, 416, 418**, and **420**. These virtual connections are shown interconnecting muxes A, B, and C through cross-connects Y and Z. Virtual connections are provisioned in between each mux. Each mux would have a virtual path to the cross-connect system that is designated for each possible destination mux. Virtual path AB contains virtual connection **412** from mux A to mux B. For calls that originate and terminate at the same mux, virtual connections **410, 416**, and **420** are provisioned for that purpose. Virtual connections **414** and **418** connect muxes A/C and B/C respectively. Alternate routes for different virtual connections can be provisioned between the same two muxes.

Within each virtual path are thousands of virtual channels (not shown). Virtual connections are provisioned by cross-connecting VPI/VCI combinations at cross-connects Y and Z. If a call enters mux A and needs to terminate at mux B, the CCM will select virtual path AB. The selection could be based on a translation of the dialed number. Within virtual path AB, the CCM would select the particular virtual channel. This selection could be based on available VCIs within the VPI. In this way, pre-provisioned virtual connections can be selected on a call by call basis.

Typically, calls will require a bidirectional voice connection. For this purpose, a virtual connection must transport user information in both directions. The virtual connections can be provisioned so that the mux at the terminating end may use the same VPI/VCI for cells transported in the opposite direction. The terminating CCM could also translate the originating VPI/VCI into another VPI/VCI provisioned in the opposite direction and provide this VPI/VCI to the terminating mux.

Additionally, the number of active virtual connections in between cross-connects can be tracked. Virtual path YZ connects cross-connects Y and Z. The capacity of virtual path YZ would be sized based on network requirements, but should it become overloaded, the CCMs can be programmed to select an alternate virtual path.

Operation Within a Network

FIG. **5** depicts an embodiment of the invention with respect to a specific telecommunications network scenario, although the invention is not limited to this specific scenario. FIG. **5** shows telecommunications system **500**. Shown are user **510**, user **512**, user **514**, user **516**, STP **518**, STP **520**, STP **522**, STP **524**, mux **526**, mux **528**, mux **530**, mux **532**, call/connection manager (CCM) **534**, CCM **536**, CCM **538**, CCM **540**, ATM cross-connect **542**, ATM cross-connect **544**, and ATM cross-connect **546**. For clarity, the connections and signaling links are not numbered. All of these components are described, and the CCMs are also discussed below.

In operation, user **510** may forward an **800** call to system **500**. User **510** could be connected to mux **526** with a DS3 connection. The **800** call would occupy a DS**0** embedded in the DS**3** connected to mux **526**. User **510** would send an SS**7** Initial Address Message (IAM) through STP **518** to system **500**. STP **520** would be configured to route the IAM to CCM **534**. An IAM contains information such as the dialed number, the caller's number, and the circuit identification code (CIC). The CIC identifies the DS**0** used by user **510** for the call.

CCM **534** would process the IAM and identify that the call was an **800** call. Either through its own database or by accessing a service control point (SCP) (not shown), the CCM would translate the dialed number based on the **800** subscriber's routing plan. For example, **800** calls from user **510** may be routed to user **512** during business hours, to user **514** at night, and to user **516** on weekends. If the call is placed from user **512** on a weekend, the call would be routed to user **516**. As such, CCM **534** would select a pre-provisioned virtual connection from mux **526** through ATM cross-connect **542** and ATM cross-connect **544** to mux **530**. CCM **534** would send an IAM message to CCM **538** through STP **520** and STP **522**. The IAM would indicate that a call was being routed to user **516** and would identify the selected virtual connection being used to reach mux **530**.

Typically, mux **530** would be connected to user **516** with a DS**3** connection. CCM **538** would select a DS**0** embedded in the DS3 and would send an LAM to user **516** through STP **522** and STP **524**. The CIC of the LAM would indicate that a call was being routed to user **516** over the selected DSO. User **516** would process the IAM and complete the call. When the call is answered, user **516** would transmit an answer message (ANM) through STP **524** back to system **500**.

CCM **534** would also send a UDP/IP message to mux **526** instructing it to assemble the user information in the DS**0** from user **510** into ATM cells with a cell header identifying the selected virtual connection. CCM **538** would send a UDP/IP message to mux **530** instructing it to dis-assemble ATM cells from the selected virtual connection and output the user information to the selected DS**0** to user **516**. ATM cross-connect **542** would route ATM cells from mux **526** to ATM cross-connect **544** based on the cell header. Likewise, ATM cross-connect **544** would route these cells to mux **530** based on the cell header. As such, user information for the call would flow from user **510** to user **516** over the DS**0** from user **510**, the virtual connection selected by CCM **534**, and the DS**0** to user **516** selected by CCM **538**. The muxes would implement the selections of the CCMs.

The call would require that a voice channel be available in both directions. As such, the DSOs and virtual connection would be bi-directional. Cut-through on the receive channel (from the user **516** to the user **510**) would occur after the address complete message (ACM) had been received by system **500**. Cut-through on the transmit channel (from the user **510** to the user **516**) would occur after the answer message (ANM) had been received by system **500**. This could be accomplished by not allowing mux **530** to release any cells for the call until the ANM has been received by system **500**.

If user **510** were to place the call at night, CCM **534** would determine that user **514** was the destination. Accordingly a pre-provisioned virtual connection from mux **526** through ATM cross-connect **542** and ATM cross-connect **546** to mux **528** would be selected for the call. CCM **536** would select the DS**0** to user **514**.

If user **510** were to place the call during the day, CCM **534** would determine that user **512** was the destination. Accordingly a pre-provisioned virtual connection from mux **526** through ATM cross-connect **542** and back to mux **526** would be selected for the call. CCM **534** would also select the DS**0** to user **512**.

The Call/Connection Manager (CCM)

FIGS. **6**–**12** refer to a preferred embodiment of the signaling processor, also known as the CCM, but any processor which supports the requirements stated for the invention would suffice. FIG. **6** depicts a signaling processor suitable for the invention. Signaling processor **610** would

typically be separate from the mux, but those skilled in the art appreciate that they could be housed together. Also, signaling processor may support a single mux or support multiple muxes.

Signaling processor **610** includes Message Transfer Part (MTP) level 1 **612**, MTP level 2 **615**, and MTP level 3 **620**. MTP level 1 **612** defines the physical and electrical requirements for a signaling link. MTP level 2 **615** sits on top of level 1 and maintains reliable transport over a signaling link by monitoring status and performing error checks. Together, MTP levels 1–2 provide reliable transport over an individual link. A device would need MTP level 1–2 functionality for each link it uses. MTP level 3 **620** sits on top of level 2 and provides a routing and management function for the signaling system at large. MTP level 3 **620** directs messages to the proper signaling link (actually to the MTP level 2 for that link). MTP level 3 **620** directs messages to applications using the MTP levels for access the signaling system. MTP level 3 **620** also has a management function which monitors the status of the signaling system and can take appropriate measures to restore service through the system. MTP levels 1–3 correspond to layers 1–3 of the open systems interconnection basic reference model (OSIBRF). Both the MTP 1–3 and the OSIBRF are well known in the art

Also shown for signaling processor **610** are ethernet interface **635**, platform handler **640**, message handler **645**, and data handler **650**. Ethernet interface **635** is a standard ethernet bus supporting TCP/IP which transfers signaling messages from MTP level 3 to platform handler **640**. Also, if UDP/IP is used to communicate with the muxes, ethernet interface **335** would accept the links to the muxes. Those skilled in the art will recognize other interfaces and protocols which could support these functions in accord with the invention.

In accord with this invention, the logic of the signaling interface (indicated by reference numerals **612**, **615**, **620**, and **635**) would be operational to route select ISUP messages to platform handler **640**. Technique for doing this have been discussed above. Preferably, an SS7 interface to platform handler **640** could be constructed using commercially available SS7 software interface tools. An example of such tools would be SS7 interface software provided by Trillium, Inc.

Platform handler **640** is a system which accepts ISUP and B-ISUP messages from ethernet interface **635** and routes them to message handler **645**. Preferably, platform handler **640** is configured to route messages to a particular message handler processor based on the signaling link selection (SLS) code in the message. Message handler **645** is a system which exchanges signaling with platform handler **640** and controls the connection and switching requirements for the calls. It can select and implement services and initiate echo control. It also converts signaling between ISUP and B-ISUP. Data handler **650** is a set of logic coupled to message handler **645** which processes service requests and provides data to message handler **645**. Data handler **650** also controls echo cancellers and generates billing records for the call.

In the discussions that follow, the term ISUP will include B-ISUP as well. In operation, ISUP messages that meet the proper criteria are routed by MTP and/or ATM interface **615**, MTP level 3 **620**, and ethernet interface **635** to platform handler **640**. Platform handler **640** would route the ISUP messages to message handler **645**. Message handler **645** would process the ISUP information. This might include validation, screening, and determining if additional data is needed for call processing. If so, data handler **650** would be invoked and would provide message handler **645** with the relevant data so message handler **645** could complete call processing. Message handler **645** would generate the appropriate ISUP message to implement the call and pass the signals to platform handler **640** for subsequent transmission to the designated network elements.

The distribution of functional entities among message handler **645** and data handler **650** are shown. These functional entities are well known in the art. Message handler **645** includes at least the call control function (CCF) and the service switching function (SSF). The CCF establishes and releases call connections, and the SSF recognizes triggers during call processing by the CCF and provides an interface between the CCF and the service control function (SCF). The SCF identifies services and obtains data for the service. In some embodiments, message handler **645** can include the SCF and the service data function (SDF). The SDF provides service data in real time to the SCF. Taken together, message handler **645** is able to at least control connections and recognize triggers. In some embodiments, message handler **645** can also identify services, obtain data for the services, and generate the signaling required to implement the services. Message handler **645** can provide signaling interworking (i.e. ISUP to B-ISUP), connection control, service selection and service implementation in a logically integrated package that interfaces with the network through conventional means.

Data handler **650** includes at least the SCF and the SDF. In some embodiments, message handler **645** and data handler **650** both include the SCF and the SDF and services are partitioned among the functional entities. Two other functions are shown in data handler that are not standardized functional entities. Accounting generates a billing record and echo handles the echo cancellers. Typically, an echo canceller is disabled for a data call and enabled after the data call for use on subsequent voice calls, however, other techniques are applicable.

In operation, the CCF would perform basic call processing until the SSF recognized a trigger and invoked the SCF. The SCF would identify the service associated with the trigger. The SCF would access data from the SDF in order to implement the service. The SCF would process the data from the SDF and provide the data to the CCF through the SSF. The CCF would then set-up the connections through conventional signaling to service switching points (SSPs). The SSPs are connected to the communications path and make the connections. Typically, an SSP is a switch. Also, echo cancellers may be controlled for the call, and a billing record could be generated for the call.

Those skilled in the art are aware of various hardware components which can support the requirements of the invention. For example, the platform handler, message handler, and data handler could each reside on a separate SPARC station **20**.

The Platform Handler

FIG. **7** shows a possible version of the platform handler. Platform handler **710** is shown. Platform handler **710** includes STP handler **712**, supervisor **714**, and CCM handler **716**. Platform handler **710** transmits and receives ISUP messages to/from the signaling interface (reference numerals **312**, **315**, **320**, and **335**). STP handler **712** would provide the ethernet—TCP/IP interface. STP handler **712** has a process to buffer and dis-assemble the incoming packets to the CCM, and buffer and assemble outgoing packets. STP

handler **712** could also check the messages for basic flaws. Any technique for transfer of signaling messages to platform handler **710** is contemplated by the invention.

Supervisor **714** is responsible for managing and monitoring CCM activities. Among these are CCM start-up and shut-down, log-in and log-off of various CCM modules, handling administrative messages (i.e. error, warning, status, etc.) from the CCM modules, and handling messages from network operations such as queries, configuration instructions, and data updates. The connection to network operations is the man machine interface which allows the CCM to be controlled and monitored by either a remote or a local operator. Supervisor **714** has a process which retrieves configuration data from internal tables to initialize and configure the CCM. The CCM modules also have internal tables which are used in conjunction with this procedure. Supervisor **714** also communicates internally with STP handler **712** and CCM handler **716**.

CCM handler **716** exchanges ISUP information with STP handler **712**. CCM handler **716** also exchanges ISUP messages and CCM supervisory messages with the message handler. The connection between CCM handler **716** and the message handler could be an ethernet LAN transporting these messages encapsulated in TCP/IP packets, but other methods are known. CCM handler **716** would provide the ethernet—TCP/IP interface. CCM handler **716** has a process to buffer and dis-assemble the incoming packets from the message handler, and buffer and assemble outgoing packets to the message handler. CCM handler **716** could also check the messages for basic flaws.

Internally, platform handler **710** is equipped with bi-directional channels which exchange information among STP handler **712**, supervisor **714**, and CCM handler **716**. The channels between STP handler **712**, CCM handler **715**, and supervisor **712** carry supervisory and administrative information. The channel between STP handler **712** and CCM handler **716** carries ISUP message information.

Platform handler **710** accepts, disassembles, and buffers ISUP messages received from the network. It can perform basic checks on the messages before transferring them to the message handler. Should more than one message handler be connected to platform handler **710**, the ISUP messages could be allocated to the message handlers based on the SLS of the particular ISUP message. CCM handler **716** accepts routing instructions from the message handler for routing certain ISUP messages to select processes of the message handler. Platform handler **710** also provides supervision and a man/machine interface for the CCM.

The Message Handler.

FIG. **8** depicts a version of the message handler. Message handler **820** is shown and includes call center **821**, origination manager **822**, termination manager **823**, detection point manager **828**, feature manager **824**, auxiliary manager **825**, switching manager **826**, and local resource **827**. A primary function of message handler **820** is to process ISUP messages.

Call center **821** is the process which receives call set-up messages from the platform handler. ISUP call set-up is initiated with the LAM. When call center **821** receives an IAM, it creates an instance of an origination manager process with data defined by the information in the IAM. Origination manager **822** represents any of the origination manager processes spawned by call center **821**. The CCM handler is instructed of the new instance so that subsequent ISUP messages related to that call can be transferred directly to the appropriate instance of origination manager **822** by the platform handler.

Origination manager **822** sets up a memory block called an originating call control block. The call control block provides a repository for information specific to a call. For example, the originating call control block could identify the following: the call control block, the origination manager, the message handler, the originating LEC, the LEC trunk circuit (CIC), the ATM virtual circuit, the ATM virtual path, the caller's number, the dialed number, the translated dialed number, the originating line information, the ANI service class, the selected route, the number of the selected route, the SLS, the OPC, the DPC, the service indicator (SIO), echo cancellation status, reason of release, call status, and pointers to adjacent call control blocks. In addition, the call control block would also contain the various times that signaling messages are received, such the address complete message (ACM), the answer message (ANM), the suspend message (SUS), the resume message (RES), and the release message (REL). Those skilled in the art would be aware of other pertinent data to include.

Origination manager **822** executes call processing in accordance with the Basic Call State Model (BCSM) recommended by the International Telecommunications Union (ITU), but with some notable exceptions. Origination manager **822** processes the IAM through each point in call (PIC) until a detection point (DP) is encountered. When a detection point is encountered, a message is sent to detection point manager **828** and processing is suspended at origination manager **822** until detection point manager **828** responds. An example of a detection point for origination manager **822** would be to authorize an origination attempt.

Detection point manager **828** accepts messages from originating manager **822** caused by a detection point encountered during call processing. Detection point manager **828** will identify whether or not the detection point is armed. An armed detection point has specific criteria which can affect call processing if met. If the detection point is not armed, detection point manager **828** will send a continue signal back to origination manager **822**. A continue message instructs origination manager **822** to continue call processing to the next detection point. If the detection point is armed, detection point manager **828** will take action to see if the detection point criteria are met. If detection point manager **828** requires assistance to process the armed detection point, it will send a message to feature manager **824**.

Feature manager **824** would accept messages from detection point manager **828** and either forward the a message to auxiliary manager **825** or to switching manager **826**. Particular feature messages would be routed to auxiliary manager **825** which will process these call features. These are typically non-IN features, such as echo control or POTS billing. Other feature messages would be routed to switching manager **826**. These are typically IN features. Examples of IN features are **800** number translation or a terminal mobility number translation. Feature manager **824** will pass information back to detection point manager **828** (then to origination manager **822**) when it is received back from auxiliary manager **825** or switching manager **826**.

Switching manager **826** which will determine if the request will be handled by local resource **827** or by the data handler. Local resource **827** will be structured to provide data more efficiently stored at message handler **820**. Examples of such data include: an automatic number identification (ANI) validation table which checks the caller's number, a dialed number translation table to translate POTS

numbers into a routing instructions, or **N00** translation tables to translate select **800** numbers into routing instructions. Examples of a routing instruction yielded by the tables would be a particular access connection or a virtual connection. An example of data in the data handler would be virtual private network (VPN) routing tables or complex **800** routing plans.

Typically, originating manager **822** will execute through the pertinent points in call to a point indicating that set up is authorized. At this point, origination manager **822** will instruct call center **821** to create an instance of a termination manager. Termination manager **823** represents any of these termination managers. Origination manager **822** will also transfer IAM information to termination manager **823**. Termination manager **823** sets up a memory block called a terminating call control block. The call control block provides a repository for information specific to a call and is similar in composition to the originating call control block.

Termination manager **823** also operates in accord with the BCSM of the ITU, but also with some exceptions. Termination manager **823** continues processing for the call through its own points in call until detection points are encountered. When a detection point is encountered, a message is sent to detection point manager **828** and processing is suspended at termination manager **823** until detection point manager **828** responds. An example of detection point for termination manager **822** would be to authorize termination which would entail authorizing the call as set-up by origination manager **822**. Messages from termination manager **823** to detection point manager **828** are handled as discussed above for messages from originating manager **822**. When processing by termination manager **823** is complete, it will produce a signaling message to transmit through platform handler **410** to the appropriate multiplexers, and possibly to the users.

Message handler **820** communicates with the data handler using a data transfer protocol. Examples include UDP/IP, or the Intelligent Network Applications Protocol (INAP) which is contained within the component sublayer of Transaction Capabilities Application Part (TCAP).

The Data Handler

FIG. **9** shows a version of the data handler. Data handler **930** is shown. Data handler **930** includes service control center **931**, service selection **932**, service logic center **933**, feature process **934**, service data center **935**, service data manager **936**, echo control **937**, and accounting **938**. Data handler **930** receives service request messages from the message handler. These messages result from an armed detection points triggering the message handler to invoke data handler **930**. The messages also result from features implemented through the auxiliary manager. Service control center **931**, service logic center **933**, and service data center **935** are static processes created at start-up. Service control center **931** creates instances of service selection managers on a call by call basis. Service control center **931** notifies the Switching manager to route subsequent service request messages for that call to the appropriate service selection manager. Service selection manager **932** represents any of the service selection managers created by service control center **931**.

Service selection manager **932** executes the service portion of the call processing. Service selection manager **932** identifies the various services associated with each message and implements the service through messages to service logic center **933**. Service logic center **933** accepts messages from service selection **932** and creates instances of the feature processes required for the identified services. Examples of feature processes are **N00**, messaging, personal/terminal mobility, and virtual private network (VPN). Feature processes are service logic programs which implement the required services for a call. Feature process **934** represents any of the feature processes created by service logic center **933**. Feature process **934** accesses the network resources and data required to implement the service. This would entail executing service independent blocks (SIBs). A SIB is a set of functions. An example of a function would be to retrieve the called number from a signaling message. SIBs are combined to build a service. An example of a SIB is translating a called number.

Those skilled in the art are familiar with the above services, although they have never been implemented by a system such as the present invention. **N00** services are services such as 800, 900, or 500 calling in which the dialed number is used to access call processing and billing logic defined by the subscriber to the service. Messaging entails connecting the caller to a voice messaging service. For example, the receipt of a release message (REL) with a cause of busy could be a trigger recognized by the message handler. In response, the data handler would create an instance of the messaging feature process and determined if a call placed to a particular dialed number would require the voice messaging platform. If so, the CCM would instruct an SSP to connect the caller to the voice message platform. Personal/Terminal mobility includes recognizing that the dialed number has mobility that requires a database look-up to determine the current number. The database is updated when the called party changes locations. VPN is a private dialing plan. It is used for calls from particular dedicated lines, from particular calling numbers (ANIs), or to particular dialed numbers. Calls are routed as defined for the particular plan.

In the execution of the SIB to provide the service, feature process **934** would invoke service data center **935** to create an instance of service data manager **936**. Service data manager **936** accesses the network databases that provide the data required for the service. Access could be facilitated by TCAP messaging to an SCP. Service data manager **936** represents any of the service managers created by service data center **935**. Once the data is retrieved, it is transferred back down to feature process **934** for further service implementation. When the feature processes for a call finish execution, service information is passed back down to the message handler and ultimately to the origination or termination manager for the call.

After a release message on a call, billing requests will be forwarded to accounting **938**. Accounting **938** will use the call control block to create a billing record. The call control block would contain information from the ISUP messages for the call and from CCM processing. From the address complete message (ACM), the call control block would include the routing label, CIC, message type, and cause indicators. From the answer message (ANM), the call control block would include the routing label, CIC, message type, and backward call indicators. From the initial address message (IAM), the call control block would include the routing label, CIC, message type, forward call indicators, user service information, called party number, calling party number, carrier identification, carrier selection information, charge number, generic address, origination line information, original called number, and redirecting number. From the release message (REL), the call control block would include the routing label, CIC, message type, and

cause indicators. From the suspend message (SUS) or the pass along message (PAM), the call control block would include the routing label, CIC, and message type. Those skilled in the art are familiar with other pertinent information for a billing record and appreciate that some of this information could be deleted.

For POTS calls, the billing request will come from the origination and termination managers through the auxiliary manager. For IN calls, the request will come from service selection **932**. Accounting **938** will generate a billing record from the call control blocks. The billing record will be forwarded to a billing system over a billing interface. An example of such an interface is the I.E.E.E. **802.3** FTAM protocol.

At some point during call set-up, the origination manager, termination manager or even the detection point process will check the user service information data and originating line information to assess the need for echo control. If the call is a data call, a message is sent to data handler **930**. Specifically, the message is routed through the auxiliary manager to the echo control manager **937** in data handler **930**. Based on the CIC, echo control manager **937** can select which echo canceller and DS**0** circuit needs to be disabled. A message will be generated to that effect and transmitted over a standard data link to the pertinent echo canceller or echo control system. As described above, echo control can be implemented by the multiplexer. Once a release (REL) message is received for the call, the echo canceller is re-enabled. On a typical call, this procedure will occur twice. Once for an echo canceller on the access side, and again for an echo canceller on the terminating side. The CCM that handles the IAM for a particular call segment will control the particular echo cancellers for the segment.

IAM Call Processing

Prior to a description of IAM processing, a brief description of SS**7** message is given. SS**7** messaging is well known in the art. SS**7** ISUP messages contain numerous fields of information. Each message will have a routing label containing a destination point code (DPC), an origination point code (OPC), and a signaling link selection (SLS) which are used primarily for routing the message. Each message contains a circuit identification code (CIC) which identifies the circuit to which the message relates. Each message contains the message type which is used to recognize the message. ISUP messages also contain mandatory parts filled with fixed length data and variable length data, in addition to a part available for optional data. These parts vary from message type to message type depending on the information needed.

The initial address message (IAM) initiates the call and contains call set-up information, such as the dialed number. IAMs are transferred in the calling direction to set up the call. During this process, TCAP messages may be sent to access remote data and processing. When the IAMs have reached the final network element, an address complete message (ACM) is sent in the backward direction to indicate that the required information is available and the called party can be alerted. If the called party answers, an answer message (ANM) is sent in the backward direction indicating that the call/connection will be used. If the calling party hangs up, a release message (REL) is sent to indicate the connection is not being used and can be torn down. If the called party hangs up, a suspend message (SUS) is sent and if the called party reconnects, a resume (RES) message keeps the line open, but if their is no re-connection, a release message (REL) is sent. When the connections are free, release complete messages (RLC) are sent to indicate that the connection can be re-used for another call. Those skilled in the art are aware of other ISUP messages, however, these are the primary ones to be considered. As can be seen, the IAM is the message that sets-up the call.

In the preferred embodiment, call processing deviates from the basic call model recommended by the ITU, although strict adherence to the model could be achieved in other embodiments. FIGS. **10–12** depicts the preferred call processing. Referring first to FIG. **10**, When the IAM for a call is received at **1005**, the call center creates an instance of an origination manager at **1010**.

The origination manager begins call processing by sending an authorize message to the detection point manager. Detection point manager checks IAM information, including the dialed number, the CIC, and the originating line information, to perform service discrimination at **1015**. This is done to determine if the service requested requires validation at **1020**. Current call processing systems and the BCSM of the ITU both validate the call before performing service discrimination. In a significant advance over the prior art, the preferred embodiment deviates from known call processing methods by looking at the IAM information prior to validation to determine if validation is even required. For example, the calling party may not pay the bill for a call. The called party pays the bill on 800 calls and validation can be unnecessary. If validation is not required at **1020**, call processing proceeds directly to B. Advantageously, this avoids unnecessary look-ups in validation tables for a significant percentage of calls.

If validation is required at **1020**, a validation table is checked at **1025**. Validation checks to see if a call should be allowed and focuses on potential billing problems for the call. For example, calls from ANIs that are delinquent on payments pose problems for billing and may not be validated. Validation would entail messaging from the detection point manager through the feature manager and the switching manager to the local resource to access the tables. The table may list authorized ANIs, unauthorized ANIs, or both. If the call is not authorized at **1030**, treatment (i.e. route to an operator or message) is given to the call at **1035**.

If the call is authorized at **1030**, the services identified at **1015** are checked at **1040** to determine if the call can be routed. This would typically occur for POTS calls. If no additional services are required at **1040**, the dialed number is translated into a route instruction at **1045**. The route instruction could be a particular virtual connection and/or access connections. The processing then proceeds to A. If additional services are required at **1040**, processing proceeds to B.

FIG. **11** picks up processing at B after a route has been selected. A termination manager is created at **1105**. The termination manager is responsible for processing in accordance with the terminating BCSM of the ITU. However, in some embodiments, the processing can exhibit some deviation. For example, detection points such as select facility and validate call may be skipped.

The bearer capability is analyzed at **1110** to determine if the call is a data call at **1115**. This analysis could occur elsewhere in the call processing (i.e by the origination manager after the route is selected.) If a data call is found at **1115**, an echo control message is sent to the data handler at **1120**. Echo control instructions are created at **1125**. The echo control instructions identify the connection for the call which requires echo control. The message could be sent to

the echo control system over a conventional data link from the CCM to the echo control system. If, the echo control is implemented in the multiplexers, the echo control message could be included with the route instruction message.

If the call is not a data call at **1115** or after echo control processing at **1125**, a signaling message is created at **1135**. The new signaling message identifies the access connections and virtual connection for the call. The new signaling message can also contain echo control instructions. The new signaling message is sent to the platform handler at **1140**.

FIG. **12** picks up the processing at B. At this point, several things are known about the call concerning authorization and service requirements. The call information is then analyzed at **1205** as required to apply services to the call. If the data handler is not required at **1210**, the service is implemented and the route is selected at **1215**. This may occur if a service can be directly implemented by the origination manager or through the local resource. For example, particular **800** translations or dialed number service profiles (i.e call forwarding) can be stored in the local resource. In this case, route selection would be performed by the local resource after the information is analyzed to identify the correct entry to a local resource database. When the local resource is used, the messages must be routed from the detection point processor through the feature manager and switching manager to the local resource.

If the data handler is required for the call at **1210**, a message is sent to the data handler at **1220**. The messaging typically flows from the detection point processor to the feature manager and switching manager to the data handler. Upon receipt of the message at the data handler, the service control center creates an instance of the service selection process at **1225**. The service selection process analyzes the message from the detection point processor and selects the feature processes for the call at **1230**. For example, a call may be placed from a caller in a virtual private network (VPN) to a PCS number. In this case, both a VPN feature process and a PCS feature process would be created.

Each feature process would determine if data was required at **1240**. For example, a personal mobility feature process would need to access a database to locate the called party's current telephone number. If data is required at **1240**, the service data center creates a service data manager at **1245**. The data manager manages the data session and accesses the appropriate database at **1250**. After the data is collected (or none is needed), the service is implemented by the feature process at **1255**. For some features, i.e. **800** service, this may include route selection. The results of the feature process analysis are returned to the origination manager to assimilate. If the feature process does not provide the route, the origination manager must select the route using the local resource or another feature process.

The IAM itself contains numerous fields of information. The following table describes the elements of an IAM with regard to the information content and call processing.

TABLE 1

Initial Address Message

Parameter Field Name	Description
ROUTING LABEL	
Service Indicator	Set a 0101-ISDN user part
Priority	0 or 1 based on destination
Network ID	10 for national network or set based on international trunk group
Destination Point Code	Destination of IAM

TABLE 1-continued

Initial Address Message

Parameter Field Name	Description
Originating Point Code	Origination of IAM
Signaling Link Connection	Link used for messages (same for all messages for the call)
Circuit ID Code	Circuit used for the call between OPC and DPC in the IAM
Message Type	0000 or 0001 for IAM
NATURE OF CONNECTION INDICATORS	
Satellite Indicator	Increment for each satellite used
Continuity Check Indicator	00 -- no check 01 -- set up check and start COT timer 10 -- start timer for COT message.
Echo Suppresser Indicator	Indicates if echo control already implemented or is set if echo control is implemented
FORWARD CALL INDICATORS	
National/International Call Indicator	0 for domestic 1 for international
End to End Method Indicator	Pass any information
Interworking Indicator	Pass any information
IAM Segmentation Indicator	0 for POTS
ISDN User Part Indicator	Pass any information
ISDN Preference Indicator	Pass any information and default to 00
ISDN Access Indicator	Pass any information
SCCP Method Indicator	00
CALLING PARTIES CATEGORY	
Calling Party Category	00000000 for unknown 00001010 for ordinary caller 00001101 for test call
USER SERVICE INFORMATION	
Information Transfer Capability	Pass any information unless destination requires particular settings, but always pass ISDN "unrestricted digital information"
Coding Standard	00
Extension	1
Information Transfer Rate	Pass any information (will be 10000 for POTS)
Transfer Mode	Set at 00 for 64 kbit/sec
Extension	1
User Layer Protocol Identification	Set based on rate adaption, typically 0100010 for user information layer 1
Extension	1 for normal calls 0 for rate adaption
Rate	Nothing for user information layer 1, but 0111 for other rate adaption
Extension	1
CALLED PARTY NUMBER	
Nature of Address Indicator	Identifies the type of call: 0000001 -- original NPA or 950 call 0000011 -- 1+ call 0000100 -- direct dial international call 1110001 -- operator call 1110010 -- operator default 1110011 -- international operator call 1110100 -- long distance operator call 1110101 -- cut through call 1110110 -- 950, hotel/motel, or non equal access call 1110111 -- test call
Odd/Even	number of digits in a called number
Numbering Plan	000 -- default 001 -- for ISDN 101 -- private
Digits Field	number of the called party
ACCESS TRANSPORT	
Access Transport Elements	pass any information

TABLE 1-continued

Initial Address Message

Parameter Field Name	Description
CALLING PARTY NUMBER	
Nature of Address Indicator	indicates the type of calling party address, unique numbers can be used for billing, but the charge number is used for non-unique numbers; 0000000 -- unknown 0000001 -- unique caller number 0000011 -- unique national number 0000100 -- unique international number 1110001 -- non-unique caller number 1110011 -- non-unique national number 1110100 -- non-unique international number 1110111 --test call
Odd/Even	Number of digits in the calling number
Screening	Not applicable
Presentation Allowed/ Restricted	Pass any information for POTS, but restrict for N00 calls that are not allowed
Numbering Plan	000 -- default 001 -- ISDN 101 -- private
Digits Field	Number of the calling party
CARRIER IDENTIFICATION	
Network Identification Plan	Number of digits in identification code for the requested carrier
Type of Network Identification	Identifies the network numbering plan for the call -- 010 for POTS call from LEC
Digit One	First digit in carrier identification code
Digit Two	Second digit in carrier identification code
Digit Three	Third digit in carrier identification code
Digit Four or Null	Fourth digit in carrier identification code (if there are four digits)
CARRIER SELECTION INFORMATION	
Carrier Selection Indicator	Indicates whether the carrier identification code was presubscribed or input
CHARGE NUMBER	
Nature of Address Indicator	This information may be used for billing. 00000001 -- caller number 00000010 -- no ANI, route to operator 00000011 -- caller's national number 00000101 -- route if 800, or route to operator 000011 -- no ANI 00001111 route if 800 or route to operator
Odd/Even	Number of digits in calling number
Numbering Plan	Pass any information
Digits Field	The number of calling party
GENERIC ADDRESS	
Nature of Address Indicator	Pass any information
Odd/Even	Pass any information
Screening	Pass any information
Presentation Allowed/ Restricted	Pass any information
Numbering Plan	Pass any information
Digits Field	Pass any information
ORIGINATING LINE INFORMATION	
Originating Line Information	Identifies particular types of calls, for example: 00000000 -- normal call 00000111 -- call from a restricted phone 00111111 -- call from a cellular roamer
ORIGINAL CALLED NUMBER	
Nature of address Indicator	Pass any information
Odd/Even	Pass any information
Screening	Pass any information
Presentation Allowed/ Restricted	Pass any information
Numbering Plan	Pass any information

TABLE 1-continued

Initial Address Message

Parameter Field Name	Description
Digits Field	Pass any information
REDIRECTING NUMBER	
Nature of Address Indicator	Pass any information
Odd/Even	Pass any information
Screening	Pass any information
Presentation Allowed/ Restricted	Pass any information
Numbering Plan	Pass any information
Digits Field	Pass any information
REDIRECTION INFORMATION	
Redirection Indicator	Pass any information
Original Redirecting Reason	Pass any information
Redirection Counter	Pass any information
Redirection Reason	Pass any information
SERVICE CODE	
Service Code	Pass any information
TRANSIT NETWORK SELECTION	
Network Identification Plan	Identifies the number of digits in the carrier identification code (3 or 4)
Type of Network Identification	Type of network identification for transit network parameter
Digits 1, 2, 3, 4	Carrier identification code of the international transit carrier
Circuit Code	Indicates how the call was dialed: 0001 -- international call no operator requested 0010 -- international call, operator requested
HOP COUNTER	
Hop Counter	limits the number of times an IAM may transfer through a signaling point. If the count reaches the limit, release the call

Subsequent ISUP Message Processing

The processing of the IAM is discussed above. Those skilled in the art are will appreciate how other SS7 messages can be incorporated into the processing of the present invention. For example, the time an address complete message (ACM) is received is recorded in the call control block for billing and maintenance. Triggers can also be based on receipt of subsequent messages, such as the ACM. The process for the answer message (ANM) is much the same.

Cut-through is the time point at which the users are able to pass information along the call connection from end to end. Messages from the CCM to the appropriate network elements are required to allow for cut-through of the call. Typically, call connections include both a transmit path from the caller and a receive path to the caller, and cut through is allowed on the receive path after the ACM is received and on the transmit path after the ANM is received.

Upon receipt of a release (REL) message, the CCM will write a time for the message to the call control block and check for triggers upon release (such as call re-originate). Additionally, any disabled echo canceller will be re-enabled, and the call control block will be used to create a billing record. Upon the receipt of a release complete message (RLC), the CCM will transmit messages directing tear down of the call path. It will clear its call specific processes and reuse the call connections for subsequent calls.

Additionally, suspend messages (SUS) and pass along messages (PAM) may be processed by the CCM. A suspend

message (SUS) indicates that the called party has disconnected and a REL will follow if the called party does not re-connect with a specified time. A PAM is simply a message between signaling points and can contain a variety of information and be used for a variety of purposes.

The invention allows switching over an ATM fabric on a call by call basis. This allows efficient high capacity virtual connections to be exploited. Advantageously, the invention does not require signaling capability in an ATM switch. The invention does not require call processing capability in an ATM switch. This enables networks to implement ATM switching without these sophisticated ATM switches that support high volumes of calls. It also avoids the cost of these switches. The invention fully supports voice traffic and non-voice traffic. The invention supports services, such as NOO, VPN, personal/terminal mobility, and voice messaging without requiring the service capability in an ATM switch. Relying on ATM cross-connects is advantageous because ATM cross-connects are farther advanced than ATM switches, and the cross-connects require less administrative support.

Those skilled in the art will appreciate that variations from the specific embodiments disclosed above are contemplated by the invention. The invention should not be restricted to the above embodiments, but should be measured by the following claims.

I claim:

1. A communication method for a call comprising:

receiving set-up signaling associated with the call into a processing system;

processing the set-up signaling in the processing system to select a DS**0** connection;

generating a message identifying the DS**0** connection;

transmitting the message from the processing system;

receiving the message and an asynchronous communication associated with the call into an interworking unit;

in the interworking unit, converting the asynchronous communication into a user communication; and

transferring the user communication from the interworking unit to the DS**0** connection in response to the message.

2. The method of claim **1** wherein transferring the user communication comprises transferring a voice communication.

3. The method of claim **1** wherein processing the set-up signaling in the processing system to select the connection comprises processing the set-up signaling in the processing system to select a trunk group.

4. The method of claim **1** wherein receiving the asynchronous communication comprises converting the asynchronous communication from an optical signal to an electrical signal.

5. The method of claim **1** wherein transferring the user communication comprises converting the user communication from an electrical signal to an optical signal.

6. The method of claim **1** wherein the asynchronous communication is in asynchronous transfer mode.

7. The method of claim **1** wherein the processing system is external to telecommunication switches.

8. The method of claim **1** wherein receiving and processing the set-up signaling to select the connection comprises receiving and processing an initial address message to select the connection.

9. The method of claim **1** wherein receiving and processing the set-up signaling to select the connection comprises receiving and processing a called number to select the connection.

10. The method of claim **1** wherein receiving and processing the set-up signaling to select the connection comprises receiving and processing a caller number to select the connection.

11. The method of claim **1** wherein processing the set-up signaling in the processing system to select the connection comprises accessing a service control point.

12. The method of claim **1** wherein processing the set-up signaling in the processing system to select the connection comprises executing a Call Control Function (CCF) and a Service Switching Function (SSF).

13. The method of claim **1** wherein processing the set-up signaling in th e processing system to select the connection comprises accessing a remote node that executes a Service Control Function (SCF).

14. The method of claim **1** wherein processing the set-up signaling in the processing system to select the connection comprises validating a call.

15. The method of claim **1** wherein processing the set-up signaling in the processing system to select the connection comprises screening a call.

16. The method of claim **1** wherein processing the set-up signaling in the processing system to select the connection comprises routing a call.

17. The method of claim **1** wherein processing the set-up signaling in the processing system to select the connection comprises processing the set-up signaling for an N00 service.

18. The method of claim **1** wherein processing the set-up signaling in the processing system to select the connection comprises processing the set-up signaling for a mobility service.

19. The method of claim **1** wherein processing the set-up signaling in the processing system to select the connection comprises processing the set-up signaling for a virtual network service.

20. The method of claim **1** wherein processing the set-up signaling in the processing system to select the connection comprises processing the set-up signaling for a voice messaging service.

21. The method of claim **1** wherein processing the set-up signaling in the processing system to select the connection comprises selecting the connection based on a translation of a called number.

22. The method of claim **1** wherein processing the set-up signaling in the processing system to select the connection comprises selecting the connection based on network loads.

23. The method of claim **1** wherein processing the set-up signaling in the processing system to select the connection comprises selecting the connection based on destination conditions.

24. The method of claim **1** further comprising storing data for the user communication identifying an originating carrier, originating circuit, the connection, caller number, called number, originating line set-up signaling, and echo cancellation status.

25. The method of claim **1** further comprising storing data for the communication identifying receipt times for an answer message and a release message.

26. The method of claim **1** further comprising processing the set-up signaling in the processing system to generate an initial address message.

27. The method of claim **1** further comprising:

processing the set-up signaling in the processing system to generate an echo cancellation instruction;

transmitting the echo cancellation instruction from the processing system;

receiving the echo cancellation instruction into the interworking unit; and

in the interworking unit, canceling echo from the asynchronous communication in response to the echo cancellation instruction.

28. The method of claim **1** further comprising:

processing the set-up signaling in the processing system to generate an encryption instruction;

transmitting the encryption instruction from the processing system;

receiving the encryption instruction into the interworking unit; and

in the interworking unit, decrypting the asynchronous communication in response to the encryption instruction.

29. The method of claim **1** further comprising:

processing the set-up signaling in the processing system to generate a compression instruction;

transmitting the compression instruction from the processing system;

receiving the compression instruction into the interworking unit; and

in the interworking unit, decompressing the asynchronous communication in response to the compression instruction.

30. The method of claim **1** further comprising:

processing the set-up signaling in the processing system to generate a decibel level instruction;

transmitting the decibel level instruction from the processing system;

receiving the decibel level instruction into the interworking unit; and

in the interworking unit, adjusting a decibel level of the user communication in response to the decibel level instruction.

31. The method of claim **1** further comprising:

processing the set-up signaling in the processing system to generate a DTMF tone detection instruction;

transmitting the DTMF tone detection instruction from the processing system;

receiving the DTMF tone detection instruction into the interworking unit; and

in the interworking unit, detecting a DTMF tone from the asynchronous communication in response to the DTMF tone detection instruction.

32. The method of claim **1** further comprising:

processing the set-up signaling in the processing system to generate a message instruction;

transmitting the message instruction from the processing system;

receiving the message instruction into the interworking unit; and

in the interworking unit, playing a message in response to the message instruction.

33. The method of claim **1** further comprising:

receiving and processing an answer message in the processing system to generate a cut-through instruction;

transmitting the cut-through instruction from the processing system;

receiving the cut-through instruction into the interworking unit; and

in the interworking unit, cutting-through the call in response to the cut-through instruction.

34. The method of claim **1** further comprising:

receiving and processing a release message in the processing system to generate a termination instruction;

transmitting the termination instruction from the processing system;

receiving the termination instruction into the interworking unit; and

in the interworking unit, terminating the call in response to the termination instruction.

35. A communication system for a call comprising:

a processing system configured to receive set-up signaling associated with the call, process the set-up signaling to select a DS**0** connection, generate a message identifying the DS**0** connection, and transfer the message; and

an interworking unit configured to receive the message and an asynchronous communication for the call, convert the asynchronous communication into a user communication, and transfer the user communication to the DS**0** connection in response to the message.

36. The communication system of claim **35** wherein the user communication comprises a voice communication.

37. The communication system of claim **35** wherein the processing system is configured to process the set-up signaling to select a trunk group.

38. The communication system of claim **35** wherein the interworking unit is configured to convert the user communication from an electrical signal to an optical signal.

39. The communication system of claim **35** wherein the interworking unit is configured to convert the asynchronous communication from an optical signal to electrical an signal.

40. The communication system of claim **35** wherein the asynchronous communication is in asynchronous transfer mode.

41. The communication system of claim **35** wherein the processing system is external to telecommunication switches.

42. The communication system of claim **35** wherein the set-up signaling comprises an initial address message.

43. The communication system of claim **35** wherein the processing system is configured to process a called number in the set-up signaling to select the connection.

44. The communication system of claim **35** wherein the processing system is configured to process a caller number in the set-up signaling to select the connection.

45. The communication system of claim **35** wherein the processing system is configured to access a service control point to select the connection.

46. The communication system of claim **35** wherein the processing system is configured to execute a Call Control Function (CCF) and a Service Switching Function (SSF).

47. The communication system of claim **35** wherein the processing system is configured to access a remote node that executes a Service Control Function (SCF).

48. The communication system of claim **35** wherein the processing system is configured to process the set-up signaling to validate a call.

49. The communication system of claim **35** wherein the processing system is configured to process the set-up signaling to screen a call.

50. The communication system of claim **35** wherein the processing system is configured to process the set-up signaling to route a call.

51. The communication system of claim **35** wherein the processing system is configured to process the set-up signaling for an N00 service.

52. The communication system of claim **35** wherein the processing system is configured to process the set-up signaling for a mobility service.

53. The communication system of claim **35** wherein the processing system is configured to process the set-up signaling for a virtual network service.

54. The communication system of claim **35** wherein the processing system is configured to process the set-up signaling for a voice messaging service.

55. The communication system of claim **35** wherein the processing system is configured to process the set-up signaling to select the connection based on a translation of a called number.

56. The communication system of claim **35** wherein the processing system is configured to process the set-up signaling to select the connection based on network loads.

57. The communication system of claim **35** wherein the processing system is configured to process the set-up signaling to select the connection based on destination conditions.

58. The communication system of claim **35** wherein the processing system is configured to store data for the communication identifying an originating carrier, originating circuit, the connection, caller number, called number, originating line set-up signaling, and echo cancellation status.

59. The communication system of claim **35** wherein the processing system is configured to store data for the communication identifying receipt times for an answer message and a release message.

60. The communication system of claim **35** wherein the processing system is configured to process the set-up signaling to generate an initial address message.

61. The communication system of claim **35** wherein:

the processing system is configured to process the set-up signaling to generate and transmit an echo cancellation instruction; and

the interworking unit is configured to receive the echo cancellation instruction and cancel echo from the asynchronous communication in response to the echo cancellation instruction.

62. The communication system of claim **35** wherein:

the processing system is configured to process the set-up signaling to generate and transmit an encryption instruction; and

the interworking unit is configured to receive the encryption instruction and decrypt the asynchronous communication in response to the encryption instruction.

63. The communication system of claim **35** wherein:

the processing system is configured to process the set-up signaling to generate and transmit a compression instruction; and

the interworking unit is configured to receive the compression instruction and decompress the asynchronous communication in response to the compression instruction.

64. The communication system of claim **35** wherein:

the processing system is configured to process the set-up signaling to generate and transmit a decibel level instruction; and

the interworking unit is configured to receive the decibel level instruction and adjust a decibel level in the user communication in response to the decibel level instruction.

65. The communication system of claim **35** wherein:

the processing system is configured to process the set-up signaling to generate and transmit a DTMF tone detection instruction; and

the interworking unit is configured to receive the DTMF tone detection instruction and detect a DTMF tone in the asynchronous communication in response to the DTMF tone detection instruction.

66. The communication system of claim **35** wherein:

the processing system is configured to process the set-up signaling to generate and transmit a message instruction; and

the interworking unit is configured to receive the message instruction and play a message in response to the message instruction.

67. The communication system of claim **35** wherein:

the processing system is configured to receive and process an answer message to generate and transmit a cut-through instruction; and

the interworking unit is configured to receive the cut-through instruction and cut-through the call in response to the cut-through instruction.

68. The communication system of claim **35** wherein:

the processing system is configured to receive and process a release message to generate and transmit a termination instruction; and

the interworking unit is configured to receive the termination instruction and terminate the call in response to the termination.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,298,064 B1
DATED : October 2, 2001
INVENTOR(S) : Joseph Michael Chrisite

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Title page,
Item [63], **Related U.S. Application Data**, replace "Continuation of application No. 09/353,401, filed on Jul. 15, 1999, which is a continuation of application No. 08/525,897, filed on Sep. 8, 1995, now Pat. No. 5,991,301, which is a continuation-in-part of application No. 08/568,551, filed on Dec. 7, 1995, now Pat. No. 5,825,780, which is a continuation of application No. 08/238,605, filed on May 5, 1994, now abandoned."
with -- Continuation of application No. 09/353,401, filed on July 15, 1999, now Pat. No. 6,473,429, which is a continuation of application No. 08/525,897, filed on Sep. 8, 1995, now Pat. No. 5,991,301, which is a continuation-in-part of application No. 08/238,605, filed on May 5. 1994, now abandoned. --

Signed and Sealed this

Twenty-seventh Day of January, 2004

Jon W. Dudas

JON W. DUDAS
Acting Director of the United States Patent and Trademark Office

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,298,064 B1 Page 1 of 1
DATED : October 2, 2001
INVENTOR(S) : Joseph Michael Christie

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Title page,
Item [63], **Related U.S. Application Data**, replace "Continuation of application No. 09/353,401, filed on Jul. 15, 1999, now Pat. No. 6,473,429, which is a continuation of application No. 08/525,897, filed on Sep. 8, 1995, now Pat. No. 5,991,301, which is a continuation-in-part of application No. 08/238,605, filed on May 5, 1994, now abandoned." with
-- Continuation of application No. 09/353,401, filed on Jul. 15, 1999, now Pat. No. 6,473,429, which is a continuation of application No. 08/525,897, filed on Sep. 8, 1995, now Pat. No. 5,991,301. --

Signed and Sealed this

Eighteenth Day of January, 2005

JON W. DUDAS
Director of the United States Patent and Trademark Office

EXHIBIT G

US006330224B1

(12) **United States Patent**
Christie et al.

(10) **Patent No.: US 6,330,224 B1**
(45) **Date of Patent: Dec. 11, 2001**

(54) **SYSTEM AND METHOD FOR PROVIDING ENHANCED SERVICES FOR A TELECOMMUNICATION CALL**

(75) Inventors: **Joseph Michael Christie,** deceased, late of San Bruno, CA (US); **Joseph S. Christie,** legal representative; **Jean M. Christie,** legal representative, both of Mt. Pleasant, PA (US); **Tracy Lee Nelson**, Shawnee Mission, KS (US)

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/272,655**

(22) Filed: **Mar. 18, 1999**
(Under 37 CFR 1.47)

Related U.S. Application Data

(63) Continuation of application No. 08/754,847, filed on Nov. 22, 1996, now Pat. No. 5,920,562.

(51) **Int. Cl.**[7] **H04J 1/16**
(52) **U.S. Cl.** **370/230**; 370/466; 370/395
(58) **Field of Search** 370/400, 351, 370/352, 353, 389, 395, 401, 402, 445, 465, 466, 467, 230, 248, 254

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,720,850 1/1988 Oberlander et al. .
4,763,317 8/1988 Lehman et al. .

(List continued on next page.)

FOREIGN PATENT DOCUMENTS

45-38569 12/1970 (JP) .
60-169318 9/1985 (JP) .
WO 95/31057 11/1995 (WO) .

OTHER PUBLICATIONS

Itu–T, "Visual Telephone Systems and Equipment for Local Area Networks Which Provide A Non–Guaranteed Quality of Service," ITU–T Recommendation, (May 28, 1996).

(List continued on next page.)

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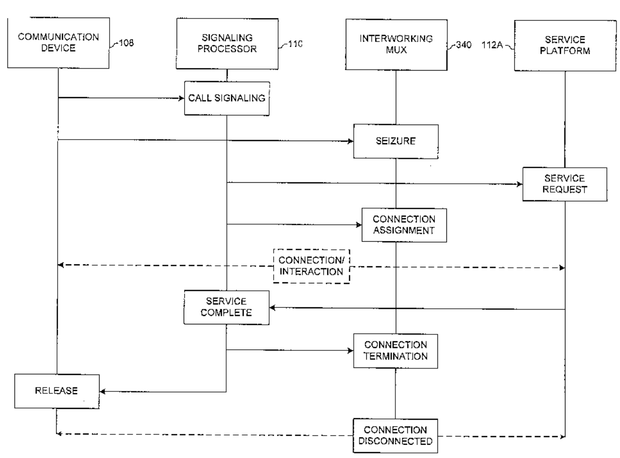
(57) **ABSTRACT**

A system and method provide enhanced services for a call that is transported from a communication device through an asynchronous transfer mode system. The call has user communications in asynchronous transfer mode cells and call signaling. A signaling processor receives the call signaling and processes the call signaling to determine a connection to a service platform. The signaling processor transports a processor control message designating the selected connection. An asynchronous transfer mode interworking unit receives the user communications from the communication device and the processor control message from the signaling processor. The asynchronous transfer mode interworking unit converts the user communications from the asynchronous transfer mode cells to a format compatible with the service platform and dynamically transports the user communications to the service platform in real time. The service platform processes the user communications. The reverse process can also take place with the dynamic transfer, in real time, of the processed user communications back to the communication device in asynchronous transfer mode cells that identify the connection to the communication device.

56 Claims, 14 Drawing Sheets



U.S. PATENT DOCUMENTS

5,051,983	9/1991	Kammerl .	
5,193,110	3/1993	Jones et al. .	
5,204,857	4/1993	Obara .	
5,218,602	6/1993	Grant et al. .	
5,251,255	10/1993	Epley .	
5,367,566	11/1994	Moe et al. .	
5,392,402	2/1995	Robrock, II .	
5,420,916	5/1995	Sekiguchi .	
5,434,852	7/1995	La Porta et al. .	
5,440,563	8/1995	Isidoro et al. .	
5,459,722	10/1995	Sherif .	
5,473,677	12/1995	D'Amato et al. .	
5,497,373	3/1996	Hulen et al. .	
5,513,355	4/1996	Doellinger et al. .	
5,519,707	5/1996	Subramanian et al. .	
5,539,884	7/1996	Robrock, II .	
5,550,820	8/1996	Baran .	
5,563,939	10/1996	La Porta et al. .	
5,587,999	12/1996	Endo .	
5,594,723	1/1997	Tibi .	
5,608,447	3/1997	Farry et al. .	
5,623,493	4/1997	Kagemoto .	
5,673,262	9/1997	Shimizu .	
5,680,390	10/1997	Robrock, II .	
5,710,769	1/1998	Anderson et al. .	
5,771,234	6/1998	Wu et al. .	
5,787,086	7/1998	McClure et al. .	
5,793,845	8/1998	Hollywood et al. .	
5,835,584	11/1998	Penttonen .	
5,867,495 *	2/1999	Elliott et al.	370/352
5,920,562	7/1999	Christie et al. .	
6,016,343	1/2000	Hogan et al. .	
6,031,840	2/2000	Christie et al. .	
6,061,364	5/2000	Hager et al. .	
6,072,798	6/2000	Beasley .	

OTHER PUBLICATIONS

Bjoern Christensen, "Tutorial: Integration of Fixed and Mobile Networks," IEEE Siemens AG, IEEE, (Feb. 2, 1996).

Bjoern E. Christensen, Tutorial: Integration of Fixed and Mobile Networks, IEEE, 1996 pp. 1–19, Melbourne.

Barry T. Dingle, ISDN Signaling Control Part (ISCP), Australian Broadband Switching and Services Symposium, 1992, pp. 333–340, vol. 2 Melbourne.

Rob Palmer, An Experimental ATM Network for B–ISDN Research, IEEE Region 10 Conference 1992, Melbourne.

Itu–T, Line Transmission of Non–Telephone Signals "Visual Telephone Systems and Equipment for Local Area Networks Which Provide a Non–Guaranteed Quality of Service" H.323 May 28, 1996, pp. 1–75.

S. L. Sutherland, Broadband ISDN Interworking, Australian Broadband Switching and Services Symposium, Jul. 1992, pp. 405–412 vol. 2, Melborune.

David Giddy et al., "An Experimental ATM Network Featuring De–Coupled Modular Control," Telecom Australia Research Laboratories (Victoria), p. 118–122, (Nov., 1992).

The ATM Forum Technical Committee, "Voice and Telephony Over ATM to the Desktop Specification," AT–V–TOA–0083.001, The ATM Forum (Mountain View, CA), p. 1–50, (Feb., 1999).

Thomas F. La Porta, "Distributed Call Processing for Wireless Mobile Networks," Bell Labs Technical Journal, vol. 1 (No. 1) p. 127–142, (Oct., 1996).

Surinder K. Jain, "Evolving Existing Narrowband Networks Towards Broadband Networks with IN Capabilities," IEEE, (Jan., 1996).

V. Carmagnola, "An Integrated IN/B–ISDN Reference Architecture for the support of Multimedia Services," IEEE, (Jan., 1996).

Yukio Kawanami, "IN Platform for DAVIC Video On Demand Service," IEEE, (Jan., 1996).

George E. Fry et al., "Next Generation Wireless Networks," Bell Labs Technical Journal, vol. 1 (No. 1), p. 88–96, (1996).

Bengt Svantesson Ahmed Hemani, "A Novel Allocation Strategy for Control and Memory Intensive Telecommunication Circuits," IEEE, p. 23–28, (Jan., 1996).

Principles of Intelligent Network Architecture, I.312/Q.1201 Integrated Services Digital Network (ISDN) I.312, CCITT (Oct., 1992).

Broadband Aspects of ISDN, I.121 Integrated Services Digital Network (IDSN) CCITT (1991).

Framework for Recommendations For Audiovisual Services, H.200 Line Transmission of Non–Telephone Signals ITU–T (Mar., 1993).

B–ISDN general network aspects, I.311 Series I: Integrated Services Digital Network ITU–T (Aug., 1996).

* cited by examiner

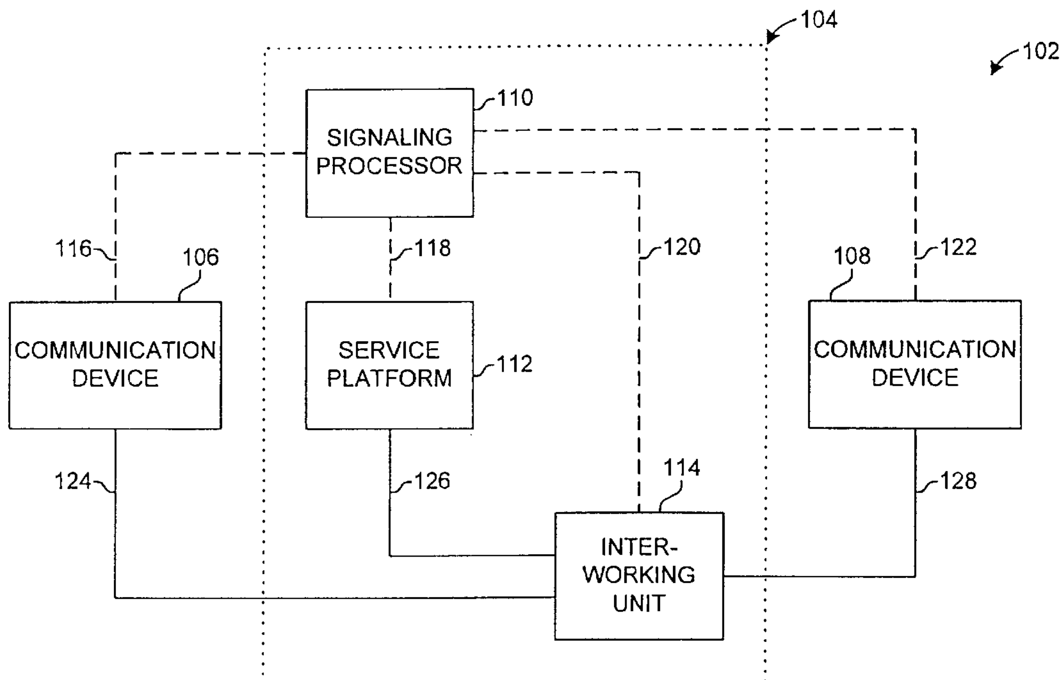

104
102
SIGNALING PROCESSOR
110
116
106
118
120
108
122
COMMUNICATION DEVICE
SERVICE PLATFORM
112
COMMUNICATION DEVICE
124
126
114
128
INTER-WORKING UNIT

FIG. 1

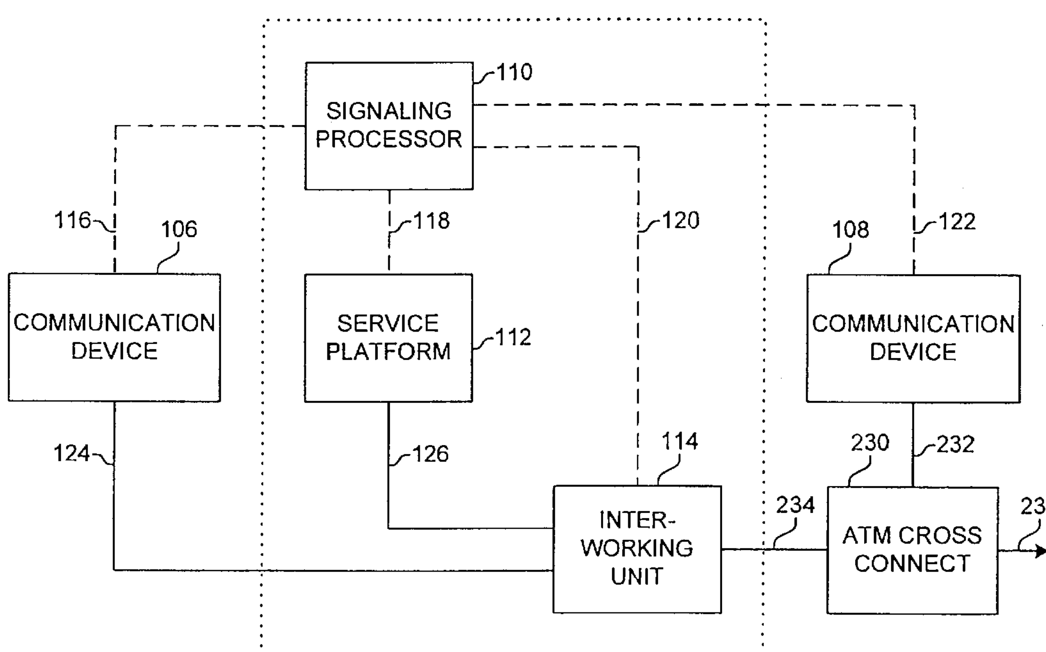

SIGNALING PROCESSOR
110
116
106
118
120
108
122
COMMUNICATION DEVICE
SERVICE PLATFORM
112
COMMUNICATION DEVICE
124
126
114
230
232
234
236
INTER-WORKING UNIT
ATM CROSS CONNECT

FIG. 2

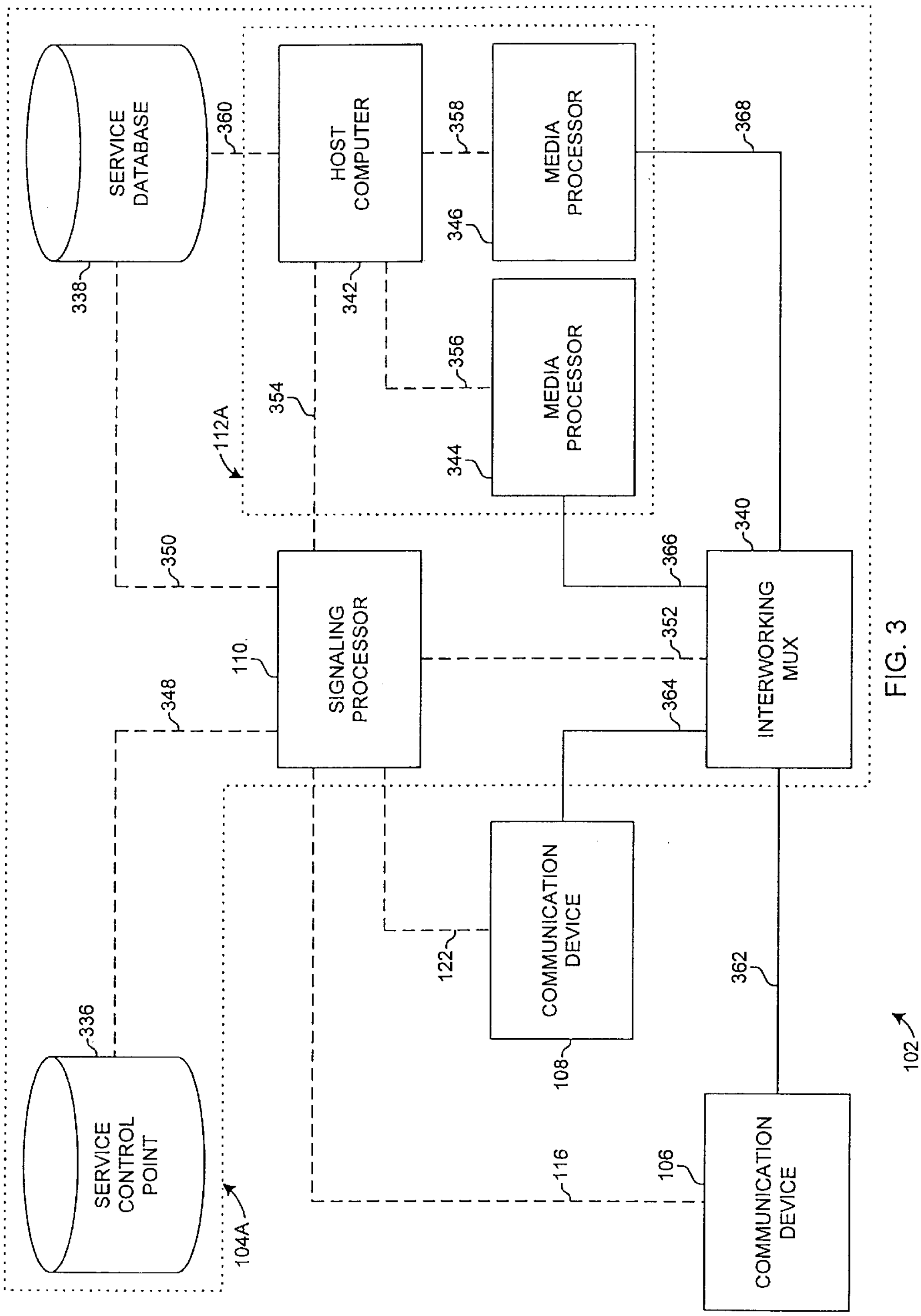

SERVICE DATABASE
338
360
HOST COMPUTER
342
358
MEDIA PROCESSOR
346
368
356
MEDIA PROCESSOR
344
354
112A
350
366
340
SIGNALING PROCESSOR
110
352
INTERWORKING MUX
348
364
COMMUNICATION DEVICE
122
108
362
336
SERVICE CONTROL POINT
104A
116
106
COMMUNICATION DEVICE
102

FIG. 3

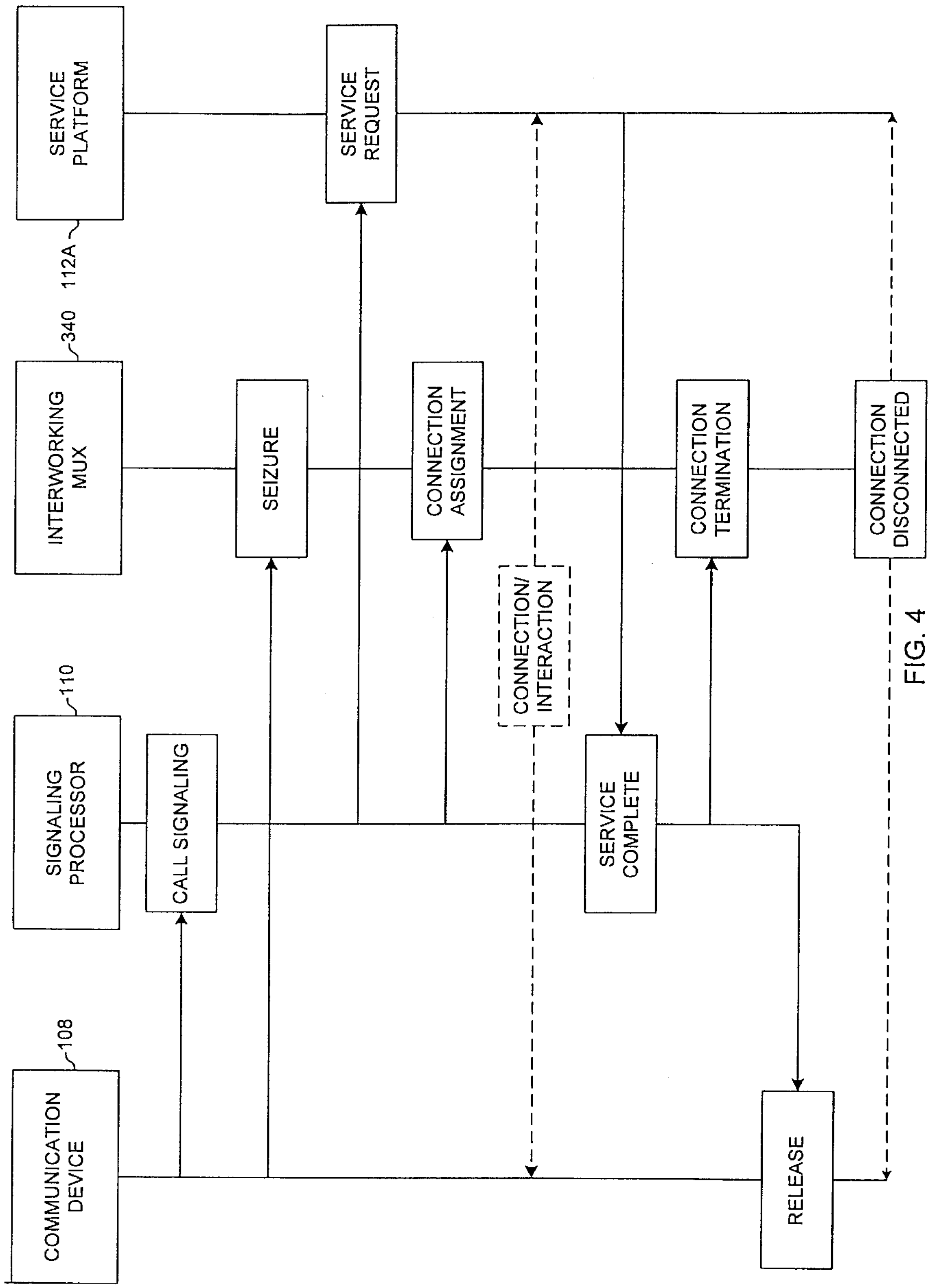
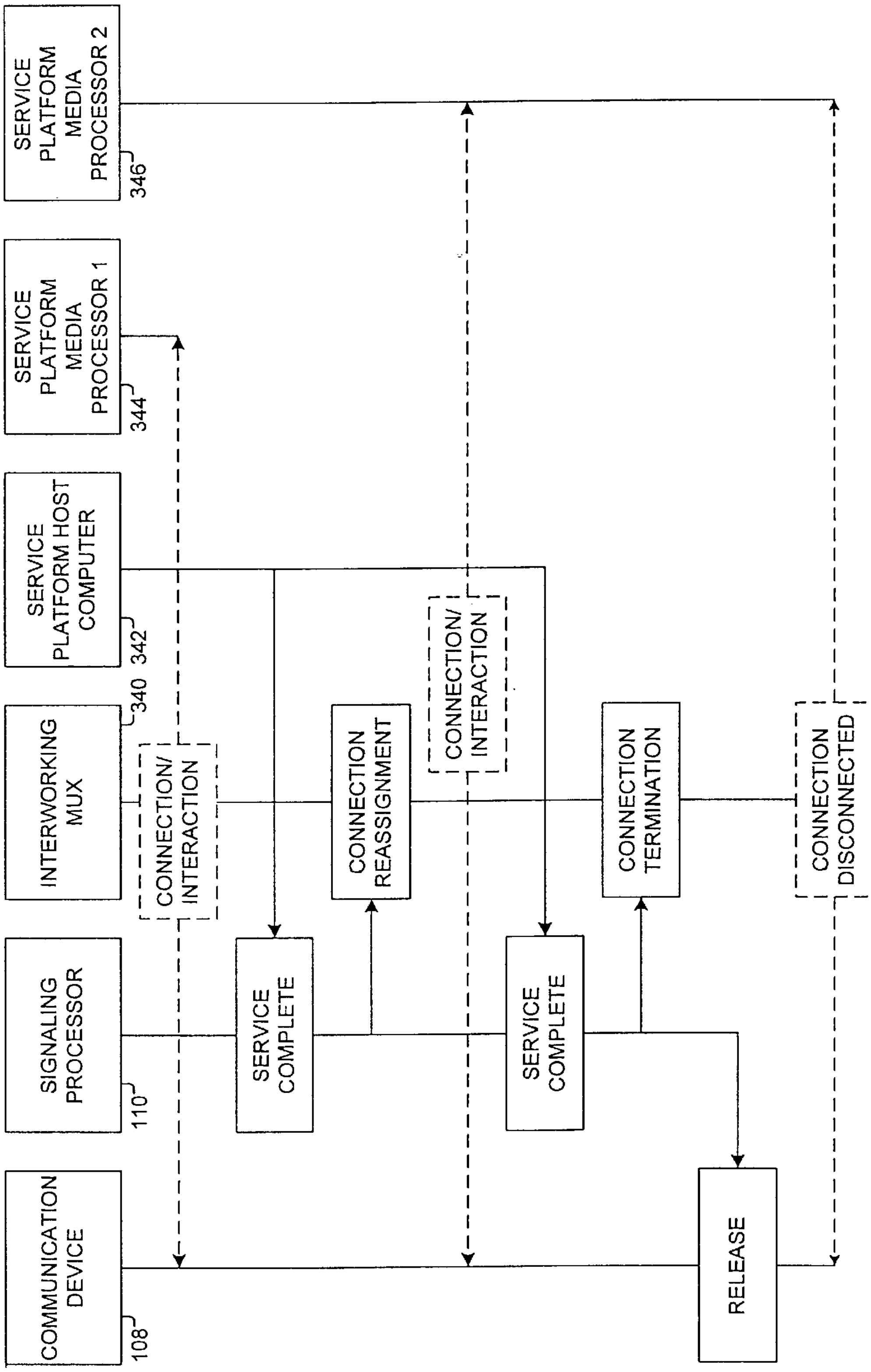

SERVICE PLATFORM
112A
INTERWORKING MUX
340
SIGNALING PROCESSOR
110
COMMUNICATION DEVICE
108
SERVICE REQUEST
SEIZURE
CONNECTION ASSIGNMENT
CONNECTION/ INTERACTION
CONNECTION TERMINATION
CONNECTION DISCONNECTED
CALL SIGNALING
SERVICE COMPLETE
RELEASE

FIG. 4



COMMUNICATION DEVICE
108
SIGNALING PROCESSOR
110
INTERWORKING MUX
340
SERVICE PLATFORM HOST COMPUTER
342
SERVICE PLATFORM MEDIA PROCESSOR 1
344
SERVICE PLATFORM MEDIA PROCESSOR 2
346
CONNECTION/ INTERACTION
SERVICE COMPLETE
CONNECTION REASSIGNMENT
CONNECTION/ INTERACTION
SERVICE COMPLETE
CONNECTION TERMINATION
RELEASE
CONNECTION DISCONNECTED

FIG. 5

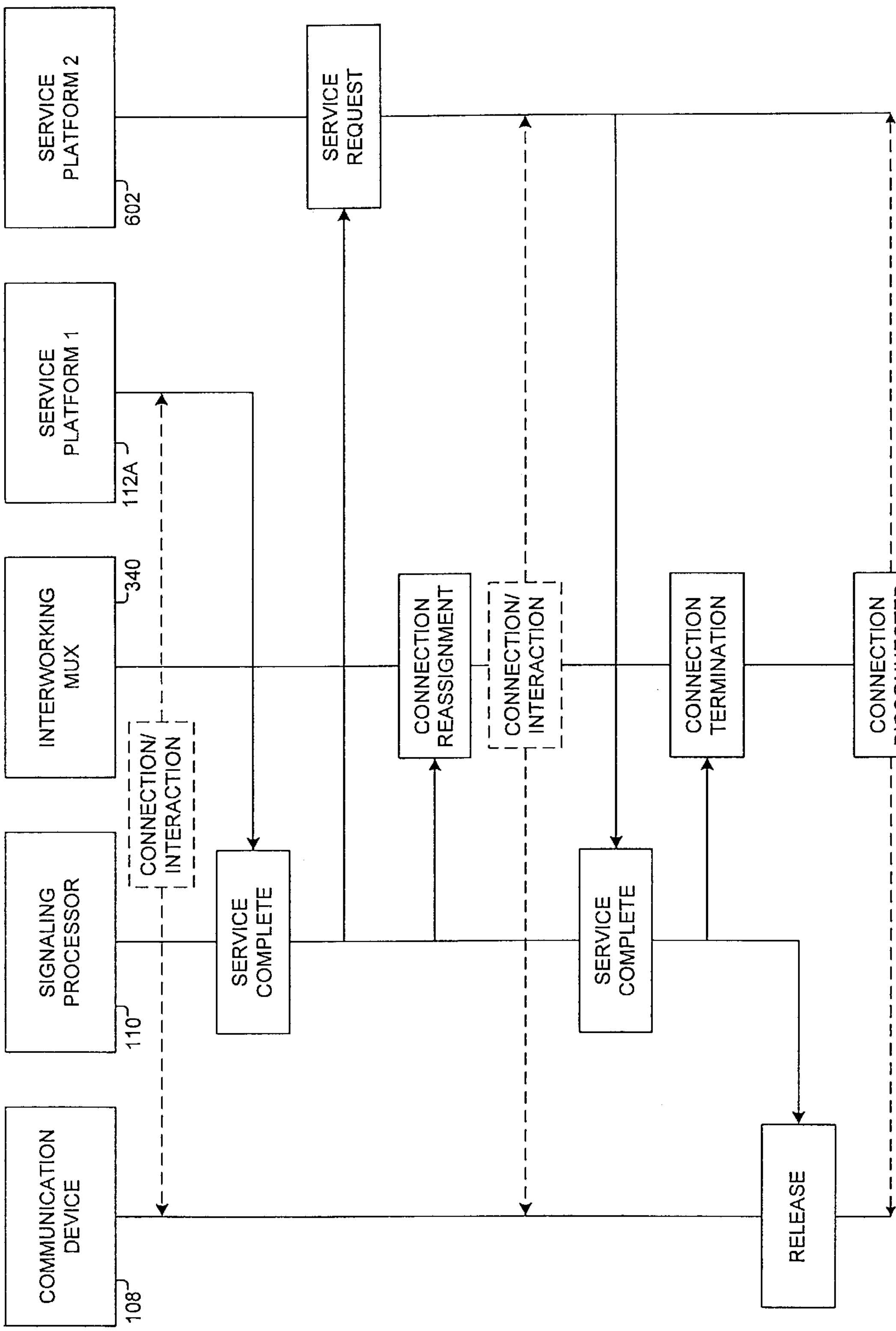

COMMUNICATION DEVICE
108
SIGNALING PROCESSOR
110
INTERWORKING MUX
340
SERVICE PLATFORM 1
112A
SERVICE PLATFORM 2
602
CONNECTION/ INTERACTION
SERVICE COMPLETE
SERVICE REQUEST
CONNECTION REASSIGNMENT
CONNECTION/ INTERACTION
SERVICE COMPLETE
CONNECTION TERMINATION
RELEASE
CONNECTION DISCONNECTED

FIG. 6

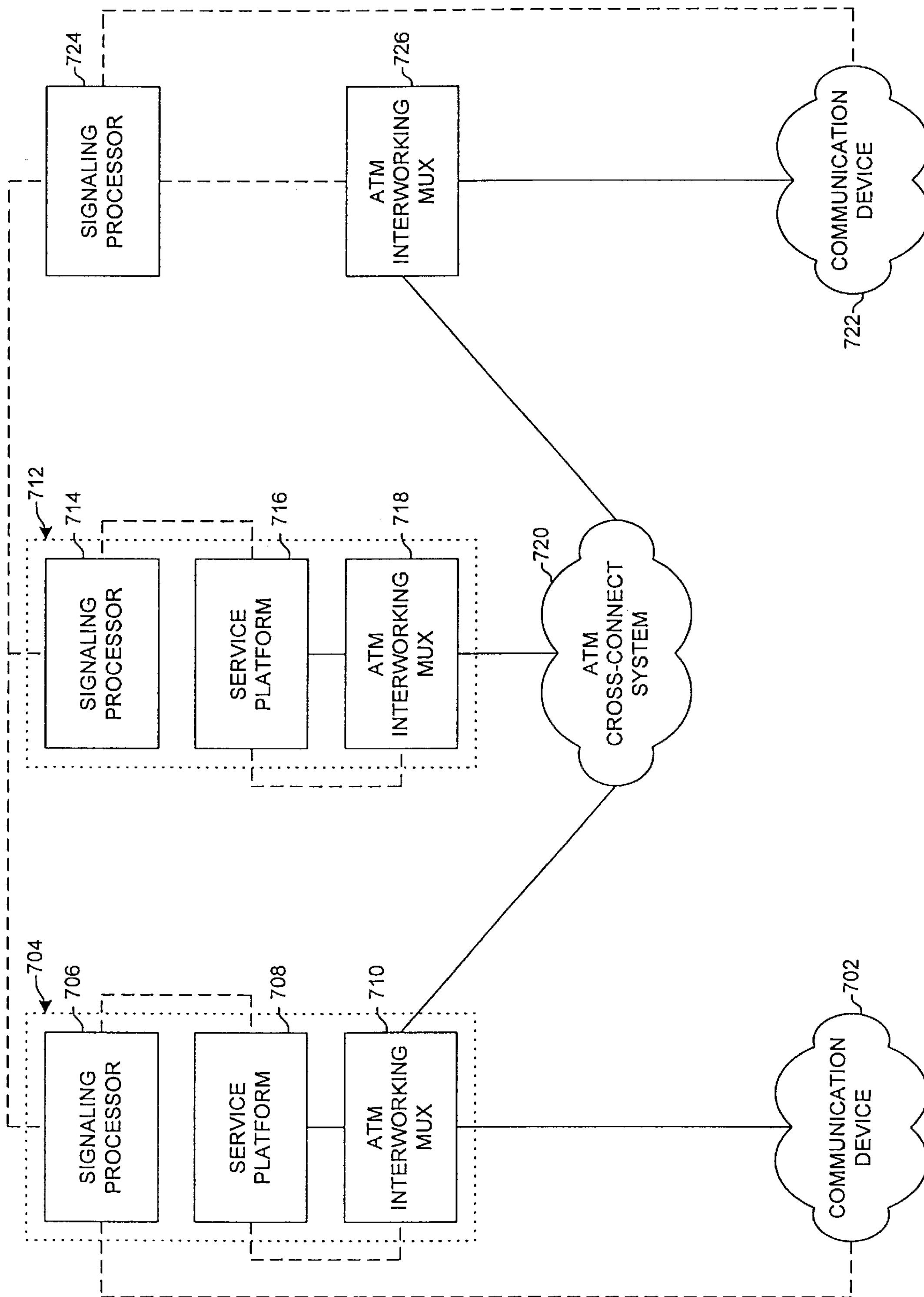

SIGNALING PROCESSOR
724
ATM INTERWORKING MUX
726
COMMUNICATION DEVICE
722
712
SIGNALING PROCESSOR
714
SERVICE PLATFORM
716
ATM INTERWORKING MUX
718
ATM CROSS-CONNECT SYSTEM
720
704
SIGNALING PROCESSOR
706
SERVICE PLATFORM
708
ATM INTERWORKING MUX
710
COMMUNICATION DEVICE
702

FIG. 7

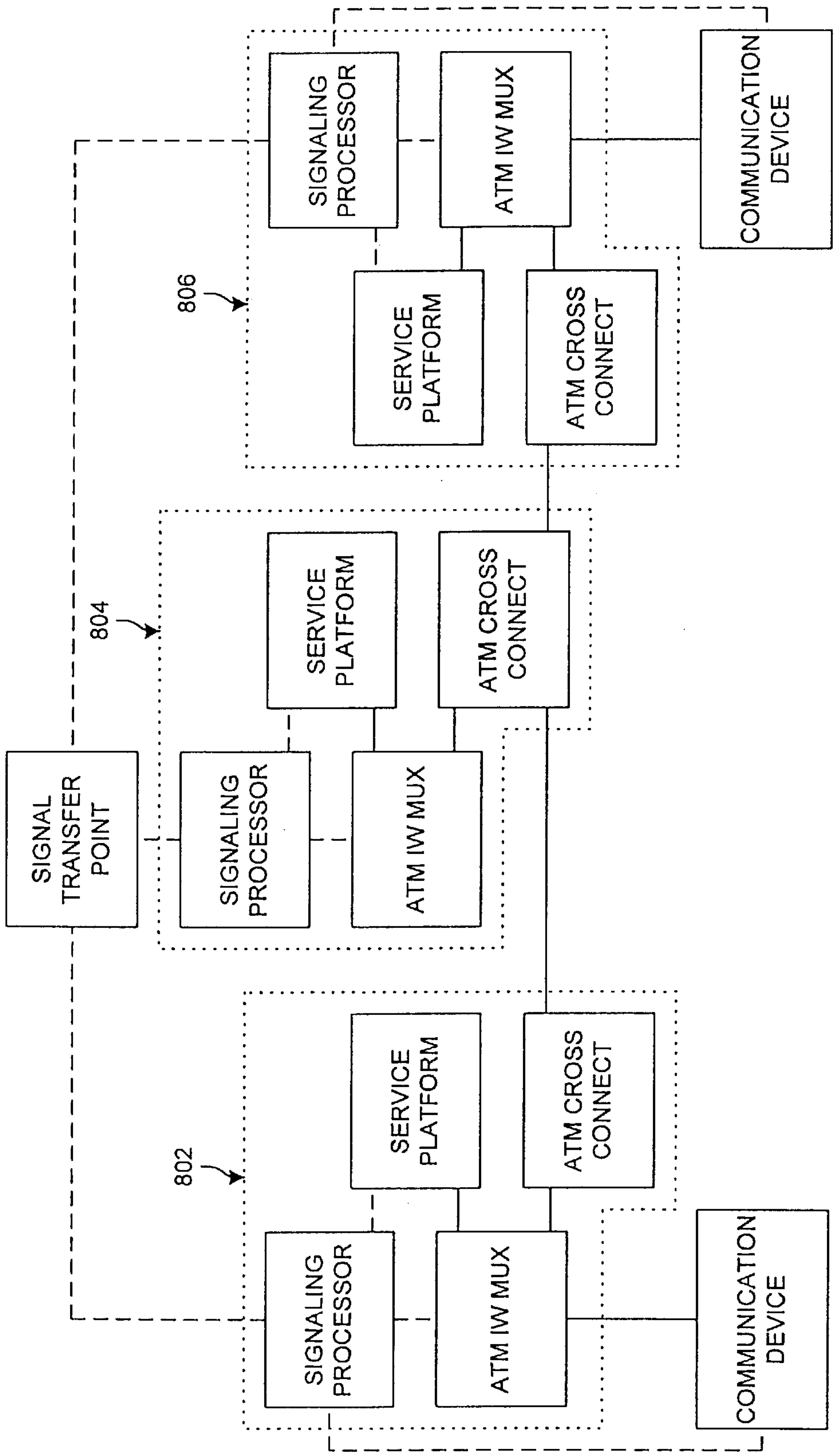

806
SIGNALING PROCESSOR
ATM IW MUX
COMMUNICATION DEVICE
SERVICE PLATFORM
ATM CROSS CONNECT
804
SERVICE PLATFORM
ATM CROSS CONNECT
SIGNAL TRANSFER POINT
SIGNALING PROCESSOR
ATM IW MUX
802
SERVICE PLATFORM
ATM CROSS CONNECT
SIGNALING PROCESSOR
ATM IW MUX
COMMUNICATION DEVICE

FIG. 8

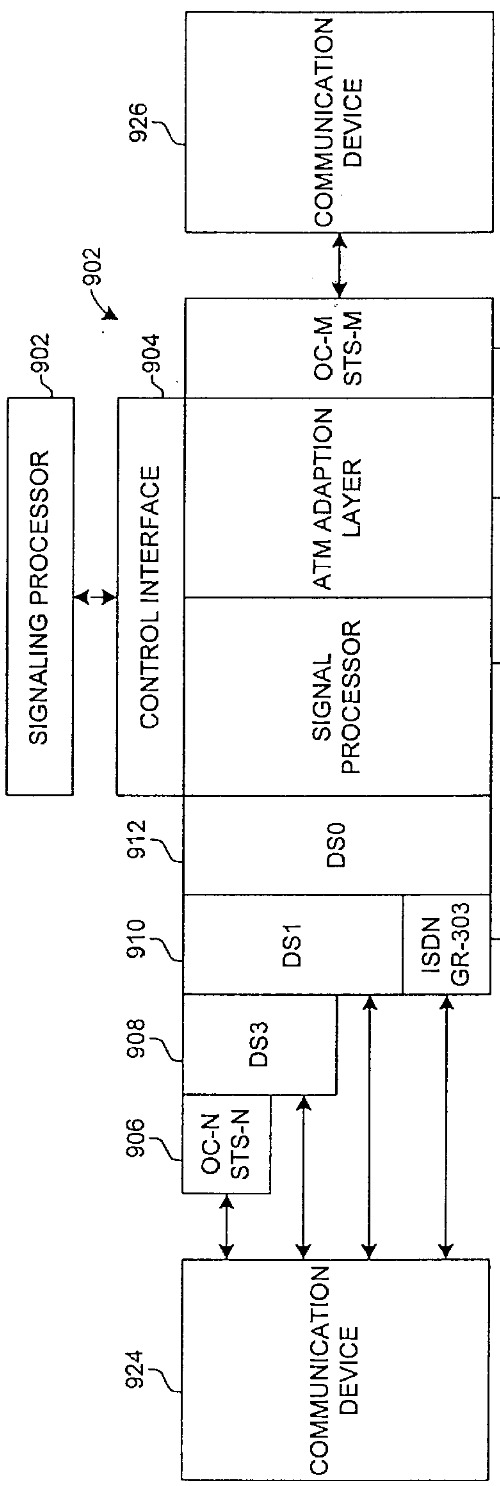

902
SIGNALING PROCESSOR
902
904
CONTROL INTERFACE
926
COMMUNICATION DEVICE
OC-M STS-M
918
ATM ADAPTION LAYER
916
SIGNAL PROCESSOR
914
912
DS0
910
DS1
ISDN GR-303
920
908
DS3
906
OC-N STS-N
924
COMMUNICATION DEVICE

FIG. 9

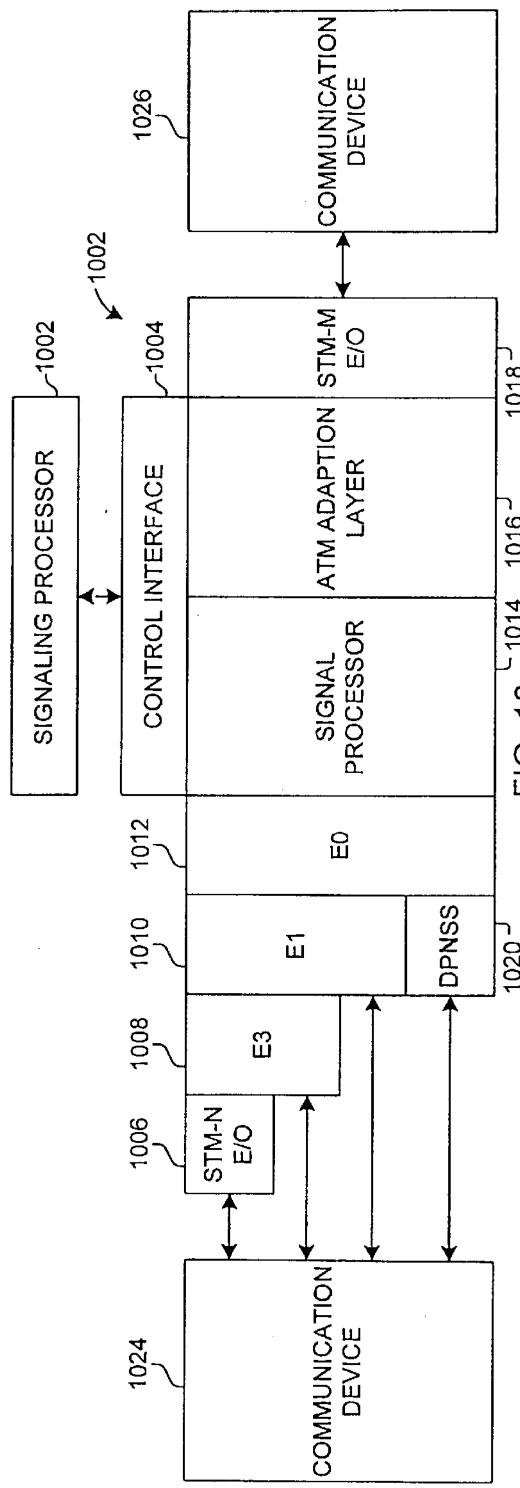

1002
SIGNALING PROCESSOR
1002
1004
CONTROL INTERFACE
1026
COMMUNICATION DEVICE
STM-M E/O
1018
ATM ADAPTION LAYER
1016
SIGNAL PROCESSOR
1014
1012
E0
1010
E1
DPNSS
1020
1008
E3
1006
STM-N E/O
1024
COMMUNICATION DEVICE

FIG. 10

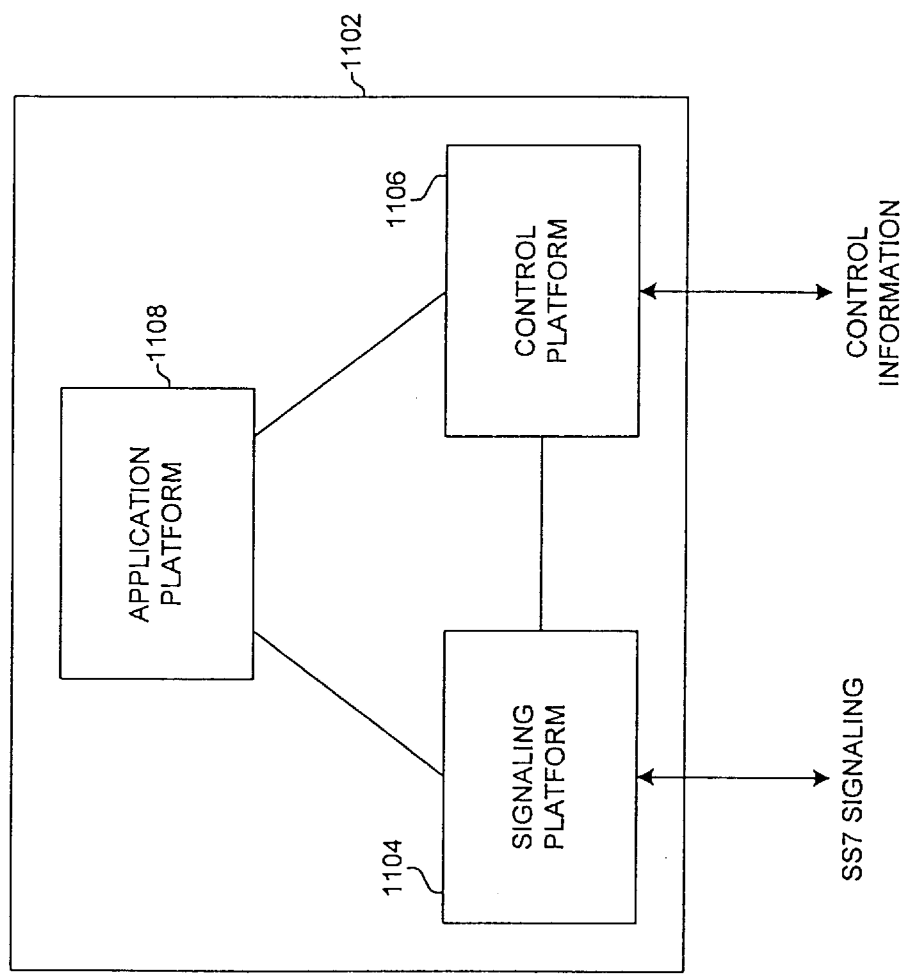

1102
1106
CONTROL PLATFORM
1108
APPLICATION PLATFORM
CONTROL INFORMATION
SIGNALING PLATFORM
1104
SS7 SIGNALING

FIG. 11

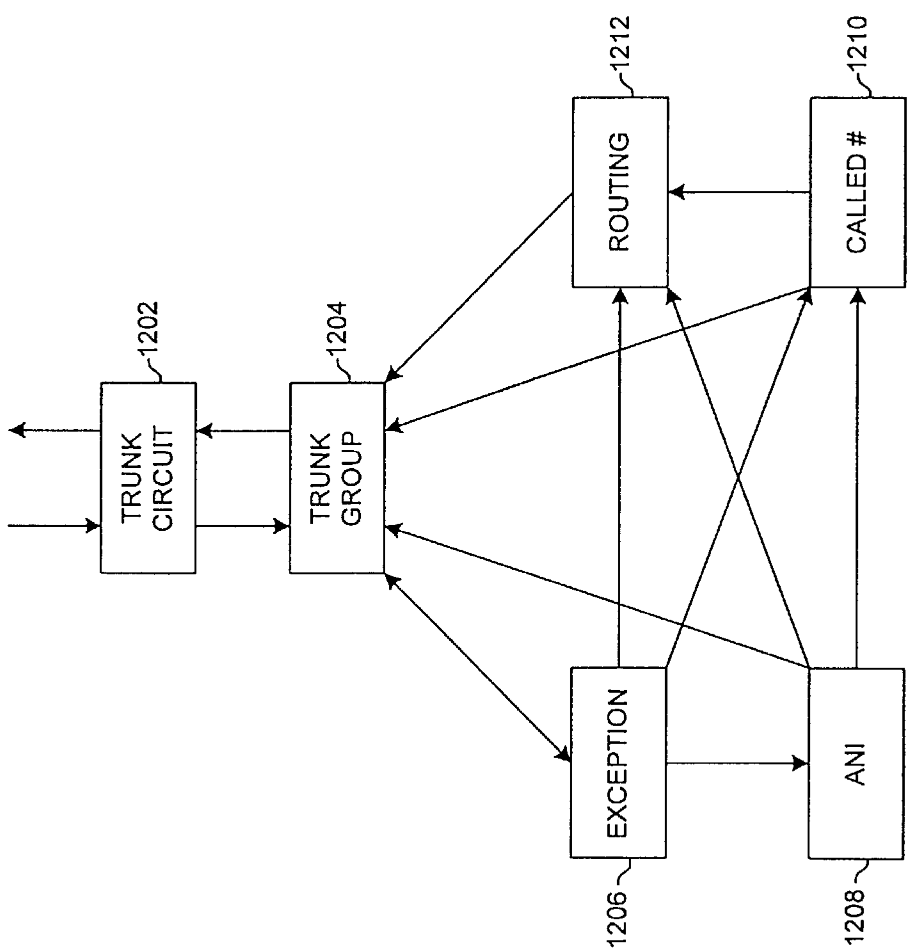
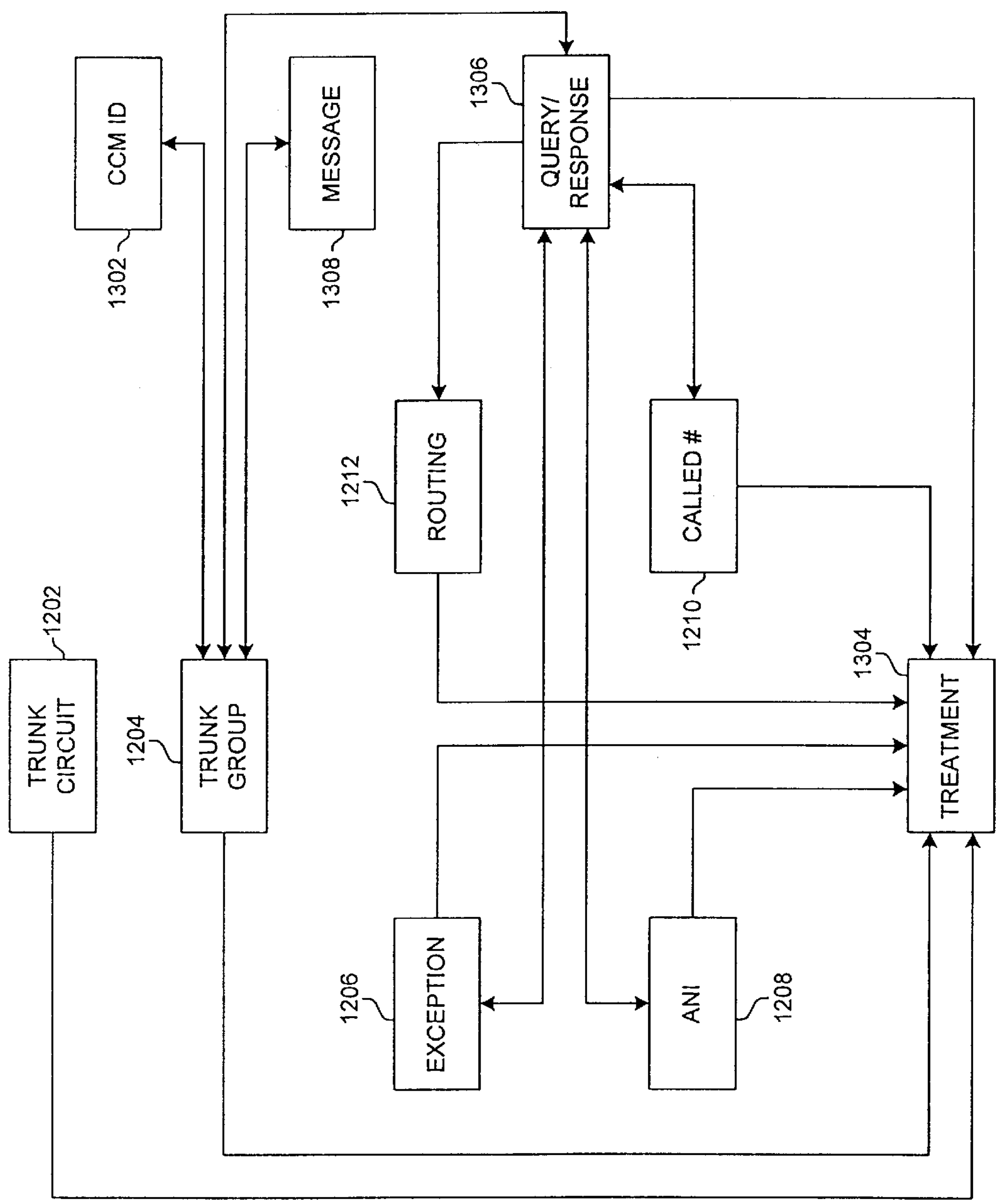

TRUNK CIRCUIT
1202
TRUNK GROUP
1204
ROUTING
1212
CALLED #
1210
EXCEPTION
1206
ANI
1208

FIG. 12



CCM ID
1302
MESSAGE
1308
1306
QUERY/ RESPONSE
1212
ROUTING
CALLED #
1210
1202
TRUNK CIRCUIT
1204
TRUNK GROUP
1304
TREATMENT
1206
EXCEPTION
ANI
1208

FIG. 13

ASSOCIATED POINT CODE	CIC	VP	VC	TRUNK GROUP NUMBER	GROUP MEMBER NUMBER	HARDWARE IDENTIFIER	ECHO CANCELER	ECHO CONTROL	SATELLITE INDICATOR	CIRCUIT STATUS	CIRCUIT STATE	TIME/ DATE

FIG. 14

TRUNK GROUP NUMBER	GLARE RESOLUTION	CONTINUITY CONTROL	CLLI	SATELLITE TRUNK GROUP	SERVICE INDICATOR	ASSOCIATED NPA	SELECTION SEQUENCE	HOP COUNTER	ACC ACTIVE	OMI	NEXT FUNCTION	INDEX

FIG. 15

EXCEPTION TABLE INDEX	CARRIER SELECTION IDENTIFICATION	CARRIER IDENTIFICATION	CALLED PARTY			NEXT FUNCTION	INDEX
			NATURE OF ADDRESS	DIGITS FROM	DIGITS TO		

FIG. 16

ANI TABLE INDEX	CALLING PARTY CATEGORY	NATURE OF ADDRESS	CALLING PARTY/CHARGE NUMBER			ORIGINATING LINE INFORMATION	NEXT FUNCTION	NEXT INDEX
			DIGITS FROM	DIGITS TO	DATA			

FIG. 17

CALLED NUMBER TABLE INDEX	NATURE OF ADDRESS	DIGITS FROM	DIGITS TO	NEXT FUNCTION	NEXT INDEX

FIG. 18

ROUTING TABLE INDEX	TRANSIT NETWORK SELECTION			CIRCUIT CODE	NEXT FUNCTION #1	INDEX #1	NEXT FUNCTION #2	INDEX #2	NEXT FUNCTION #3	INDEX #3
	NETWORK IDENTIFICATION PLAN	DIGITS FROM	DIGITS TO							

FIG. 19.

INDEX	MESSAGE RECEIVED CAUSE VALUE	GENERAL LOCATION	CODING STANDARD	CAUSE VALUE	NEXT FUNCTION	INDEX

FIG. 20

MESSAGE TYPE	PARAMETERS	INDEX #1	INDEX #....	INDEX #N
ADDRESS COMPLETE	BACKWARD CALL INDICATOR			
	ACCESS TRANSPORT			
	CAUSE INDICATOR			
	OPTIONAL BACKWARD CALL INDICATORS			
	OPTIONAL "FE" INDICATOR			
ANSWER	ACCESS TRANSPORT			
	BACKWARD CALL INDICATOR			
CALL PROGRESS	EVENT INFORMATION			
	BACKWARD CALL INDICATOR			
	ACCESS TRANSPORT			
	CAUSE INDICATOR			
	OPTIONAL BACKWARD CALL INDICATOR			
CIRCUIT RESERVATION	NATURE OF CONNECTION INDICATOR			
CIRCUIT RESERVATION ACK	N/A			
CONFUSION	N/A			
CONTINUITY	CONTINUITY INDICATOR			
EXIT	OUTGOING TRUNK GROUP NUMBER			
INFORMATION	ALL PARAMETERS			
INFORMATION REQUEST	ALL PARAMETERS			
INITIAL ADDRESS	NATURE OF CONNECTION INDICATOR			
	FORWARD CALL INDICATOR			
	CALLING PARTY'S CATEGORY			
	USER SERVICE INFORMATION			
	CALLED PARTY NUMBER			
	ACCESS TRANSPORT			
	CALLING PARTY NUMBER			
	CARRIER IDENTIFICATION			
	CARRIER SELECTION INFORMATION			
	CHARGE NUMBER			
	GENERIC ADDRESS			
	ORIGINATING LINE INFORMATION			
	ORIGINAL CALLED NUMBER			
	REDIRECTING NUMBER			
	SERVICE CODE			
	TRANSIT NETWORK SELECTION			
	HOP COUNTER			
PASS ALONG	ALL PARAMETERS			
RELEASE	CAUSE INDICATOR			
	ACCESS TRANSPORT			
	AUTOMATIC CONGESTION CONTROL			
RELEASE COMPLETE	N/A			
RESUME	SUSPEND/RESUME INDICATOR			
SUSPEND	SUSPEND/RESUME INDICATOR			

FIG. 21

SYSTEM AND METHOD FOR PROVIDING ENHANCED SERVICES FOR A TELECOMMUNICATION CALL

RELATED APPLICATIONS

This application is a continuation of prior application Ser. No. 08/754,847, filed Nov. 22, 1996 now U.S. Pat. No. 5,920,562 and entitled "SYSTEM AND METHOD FOR PROVIDING ENHANCED SERVICES FOR A TELECOMMUNICATION CALL", and which is incorporated by reference into this application.

FEDERALLY SPONSERED RESEARCH OR DEVELOPMENT

Not applicable

MICROFICHE APPENDIX

Not applicable

FIELD OF THE INVENTION

The present invention relates to the field of telecommunications transmission and processing.

SUMMARY OF THE INVENTION

The present invention comprises a system for providing services for a call from a first communication device in an asynchronous transfer mode format. The call has user communications and call signaling. The system comprises a service platform adapted to receive the user communications. The service platform applies an interactive application to the user communications to process the user communications. The system further comprises a signaling processor adapted to receive the call signaling from the first communication device and to process the call signaling to select a first connection to the service platform. The signaling processor transports a processor control message designating the selected first connection. The system also comprises an interworking unit adapted to receive the processor control message from the signaling processor and to receive the user communications from the first communication device. The interworking unit converts the user communications from the asynchronous transfer mode format to a format usable by the service platform and uses the processor control message to transport the converted user communications to the service platform.

Further, the present invention is a system for providing services for a call from a first communication device in a time division multiplex format. The call has user communications and call signaling. The system comprises a service platform adapted to receive the user communications in an asynchronous transfer mode format. The service platform applies an interactive application to the user communications to process the user communications. The system further comprises a signaling processor adapted to receive the call signaling from the first communication device and to process the call signaling to select a first connection to the service platform. The signaling processor transports a processor control message designating the selected first connection. The system further comprises an interworking unit adapted to receive the processor control message from the signaling processor and to receive the user communications from the first communication device. The interworking unit interworks the user communications from the time division multiplex format to asynchronous transfer mode formatted cells that identify the selected first connection to the service platform.

In another aspect, the present invention is a method for connecting a call from a first communication device through an asynchronous transfer mode system. The call has user communications and call signaling. The method comprises receiving the call signaling in a signaling processor. The call signaling is processed to select a selected first one of a plurality of connections to a service platform for the user communications. A processor control message is transported from the signaling processor designating the selected first connection. The method further comprises receiving the user communications and the processor control message in an interworking unit. The user communications are converted in the interworking unit from the asynchronous transfer mode format to a format that is compatible with the service platform in response to the processor control message and transported from the interworking unit over the selected first connection to the service platform. The user communications are received in the service platform and processing the user communications.

In yet another aspect, the present invention is a method for connecting a call from a first communication device in a time division multiplex format. The call has user communications and call signaling. The method comprises receiving the call signaling in a signaling processor and processing the call signaling to select a selected first one of a plurality of connections to a service platform for the user communications. The processor control message is transported from the signaling processor designating the selected first connection. The user communications and the processor control message are received in an interworking unit. The method further comprises converting the user communications in the interworking unit from the time division multiplex format to asynchronous transfer mode formatted cells that identify the selected first connection to the service platform and transporting the converted user communications from the interworking unit over the selected first connection to the service platform. The user communications are received in the service platform and processing the user communications.

In still another aspect, the present invention is a system for connecting a call in an asynchronous transfer mode system. The call has user communications and call signaling. The system comprises a first communication device adapted to transport the call, a service node adapted to process the user communications, and a signaling processor adapted to receive the call signaling and to process the call signaling to select a connection to the service node. The signaling processor transports a processor control message designating the selected connection. The system also comprises an interworking unit located in the asynchronous transfer mode system adapted to receive the user communications from the first communication device, to receive the processor control message from the signaling processor, and to use the processor control message to route the user communications to the service node over the selected connection.

Still further, the present invention is a method for connecting a call through an asynchronous transfer mode system to a service node. The call has user communications and call signaling. The method comprises transporting the call from a communication device, the user communications comprising asynchronous transfer mode cells. The method includes receiving the call signaling in a signaling processor and processing the call signaling to select one of a plurality of connections to the service node. A processor control message is transported from the signaling processor designating the selected connection. The user communications and the processor control message are received in an inter-

working unit. The method further comprises converting the user communications from the asynchronous transfer mode cells to a format usable by the service node and using the processor control message to route the user communications to the service node over the selected connection and processing the user communications in the service node.

The present invention further comprises a method for connecting a call having user communications through an asynchronous transfer mode system. The method comprises selecting in a processor a selected one of a plurality of connections to a service platform for the user communications. An interworking unit is notified which one of the plurality of connections was selected. The user communications are received in the interworking unit. The user communications are converted in the interworking unit from the asynchronous transfer mode format to a format that is compatible with the service platform. The converted user communications are transported in real time from the interworking unit over the selected connection to the service platform.

DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of a service platform system in accordance with the present invention.

FIG. **2** is a block diagram of a service platform system operating with a time division multiplex device in accordance with the present invention.

FIG. **3** is a block diagram of a service platform system with an extended asynchronous transfer mode system in accordance with the present invention.

FIG. **4** is a message sequence chart for a service platform in accordance with the present invention.

FIG. **5** is a message sequence chart for a plurality of service platforms.

FIG. **6** is a message sequence chart for a service platform with a plurality of media processors in accordance with the present invention.

FIG. **7** is a functional diagram of a plurality of service platforms interacting in an asynchronous transfer mode system.

FIG. **8** is a block diagram of a plurality of service platforms interacting in an asynchronous transfer mode system.

FIG. **9** is a functional diagram of an asynchronous transfer mode interworking multiplexer for use with a synchronous optical network system in accordance with the present invention.

FIG. **10** is a functional diagram of an asynchronous transfer mode interworking multiplexer for use with a synchronous digital hierarchy system in accordance with the present invention.

FIG. **11** is a block diagram of a signaling processor constructed in accordance with the present system.

FIG. **12** is a block diagram of a data structure having tables that are used in the signaling processor of FIG. **11**.

FIG. **13** is a block diagram of additional tables that are used in the signaling processor of FIG. **12**.

FIG. **14** is a table diagram of a trunk circuit table used in the signaling processor of FIG. **13**.

FIG. **15** is a table diagram of a trunk group table used in the signaling processor of FIG. **13**.

FIG. **16** is a table diagram of an exception circuit table used in the signaling processor of FIG. **13**.

FIG. **17** is a table diagram of an automated number index table used in the signaling processor of FIG. **13**.

FIG. **18** is a table diagram of a called number table used in the signaling processor of FIG. **13**.

FIG. **19** is a table diagram of a routing table used in the signaling processor of FIG. **13**.

FIG. **20** is a table diagram of a treatment table used in the signaling processor of FIG. **13**.

FIG. **21** is a table diagram of a message table used in the signaling processor of FIG. **13**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A call is a request for telecommunication services. Telecommunication systems provide services and processing for telecommunication calls between communication devices. Each call has call signaling and user communications. The user communications contain the caller's information, such as a voice communication or data communication, and they are communicated over a connection. Call signaling contains information that facilitates call processing, and it is communicated over a link. Call signaling, for example, contains information describing the called number and the calling number. Examples of call signaling are standardized signaling, such as SS7, C7, integrated services data network (ISDN), and digital private network signaling system (DPNSS).

A call can be transmitted from a communication device. A communication device can be, for example, customer premises equipment, a call processing platform, a switch, or any other device capable of initiating, handling, or terminating a call. Customer premises equipment can be, for example, a telephone, a computer, a facsimile machine, or a private branch exchange. A call processing platform can be, for example, a service platform or any other enhanced platform that is capable of processing calls.

The user communications and the call signaling may be transported by a communication device through an in-band transmission, such as superframe (SF) or extended superframe (ESF), over a time division multiplex (TDM) carrier such as a digital signal (DS) level communication line. Digital signal level zero (DS0), digital signal level one (DS1), and digital signal level three (DS3) are common designations that carry in-band communications. Other equivalent designations also carry in-band traffic. For example, European communication systems such as European level one (E1), European level 2 (E2), European level 3 (E3), and European level four (E4) are common designations that carry in-band communications.

In addition, call signaling and user communications may be transported out-of-band on separate transport paths, separate transport channels, separate transport connections, or separate transport media. These transports may be carried over DS level or equivalent European level media, as well as higher speed optical and electrical systems, such as synchronous optical network (SONET) and synchronous digital hierarchy (SDH). For example, signaling system 7 (SS7) and the European equivalent, C7, transport signaling traffic out-of-band. Moreover, narrowband systems such as ISDN and broadband systems such as broadband integrated services data network (B-ISDN), including B-ISDN over asynchronous transfer mode (ATM), transport call signaling and user communications out-of-band.

Broadband systems provide greater bandwidth than narrowband systems for calls, in addition to providing digital processing of the calls, error checking, and correction. ATM is one technology that is being used in conjunction with SONET and SDH to provide broadband call switching and call transport for telecommunication services.

ATM is a protocol that describes communication of user communications in ATM cells. Because the protocol uses cells, calls can be transported on demand for connection-oriented traffic, connectionless-oriented traffic, constant-bit traffic, variable-bit traffic including bursty traffic, and between equipment that either requires timing or does not require timing.

ATM systems handle calls over switched virtual paths (SVPs) and switched virtual circuits (SVCs). The virtual nature of ATM allows multiple communication devices to use a physical communication line at different times. This type of virtual connection more efficiently uses bandwidth, and thereby provides more cost efficient transport for customer calls, than permanent virtual circuits (PVCs) or other dedicated circuits.

The ATM system is able to connect a caller from an origination point to a destination point by selecting a connection from the origination point to the destination point. The connection contains a virtual path (VP) and a virtual channel (VC). A VC is a logical connection between two end points for the transfer of ATM cells. A VP is a logical combination of VCs. The ATM system designates the selected connection by specifying a virtual path identifier (VPI) that identifies the selected VP and a virtual channel identifier (VCI) that identifies the selected VC within the selected VP. Because ATM connections are uni-directional, bi-directional communications in an ATM system usually require companion VPIs/VCIs.

The SONET and SDH protocols describe the physical media and protocols upon which the communication of ATM cells takes place. SONET includes optical transmission of optical carrier (OC) signals and electrical transmission of synchronous transport signals (STSs). SONET signals transmit at a base rate of 51.84 Mega-bits per second (Mbps) for optical carrier level one (OC-1) and synchronous transport signal level one (STS-1). Also transmitted are multiples thereof, such as an STS level three (STS-3) and an OC level three (OC-3) at rates of 155.52 Mbps and an STS level twelve (STS-12) and an OC level 12 (OC-12) at rates of 622.08 Mbps, and fractions thereof, such as a virtual tributary group (VTG) at a rate of 6.912 Mbps. SDH includes transmission of optical synchronous transport module (STM O) signals and electrical synchronous transport module (STM E) signals. SDH signals transmit at a base rate of 155.52 Mbps for synchronous transport module level one electrical and optical (STM-1 E/O). Also transmitted are multiples thereof, such as an STM level four electrical/optical (STM-4 E/O) at rates of 622.08 Mbps, and fractions thereof, such as a tributary unit group (TUG) at a rate of 6.912 Mbps.

Telecommunication systems require call setup information to initiate a connection between communication devices. The call setup uses information in the call signaling to make the correct connection between the communication devices so that the user communications can be transported across the connection between the communication devices.

Calls are placed to a service provider. The service provider processes the call signaling and, based on the information in the call signaling, provides a selected service to process the call. Many calls require only general processing and general services such as basic call routing to the destination point from the originating point or other basic services.

However, enhanced services are sometimes required for call processing. Such enhanced services are generally located at a service node in a service platform and can process the user communications in response to control messages. These enhanced services often use digital signal processing, application programs, and database storage to perform the required processing for the enhanced services. These enhanced services often provide interactive calling features that require a caller to interact with telecommunication network equipment in order to achieve an enhanced service. For example, a call might require voice recognition processing prior to allowing the caller access to an information database. Such a call would likely require enhanced services in which the caller interacts with a voice recognition processor in the telecommunication network.

A system and method are required to dynamically transfer calls through an ATM system to a service platform. The ATM system contains telecommunication communication devices, such as a communication device, a call destination device, and switching equipment, that allows the call to be transported to the correct destination in the ATM network. Thus, there is a need for a system and method to connect calls passing through an ATM system to devices, such as service platforms, that can provide enhanced services. Moreover, this should be completed on a call-by-call basis in real time.

The Service Platform Systems

The system of the present invention provides call transmission and call switching in real time in an ATM system within a telecommunication network. The system connects calls passing through the ATM system to service nodes having service platforms that can provide enhanced services for processing the calls. Moreover, it is possible to select specific interactive applications within a service platform to process each call.

FIG. **1** illustrates the use of a service platform system in accordance with the present invention. A telecommunication system **102** has a service platform system **104** that interacts with a first communication device **106** and a second communication device **108**. The service platform system **104** contains a signaling processor **110**, a service platform **112**, and an interworking unit **114**. The service platform system **104** can receive one or more calls and route the calls to the appropriate device. The service platform system **104** processes calls using interactive applications.

Links are used to transport call signaling and control messages. The term "link" as used herein means a transmission media used to carry call signaling and control messages. For example, a link carries call signaling or a device control message containing device instructions and/or data. A link can carry, for example, out-of-band signaling such as SS7, C7, ISDN, B-ISDN, GR-303, local area network (LAN), or data bus call signaling. A link can be, for example, an AAL5 data link, UDP/IP, eithernet, or a DS0 over T1. In addition, a link, as shown in the figures, can represent a single physical link or multiple links, such as one link or a combination of links of ISDN, SS7, TCP/IP, or some other data link. The term "control message" as used herein means a control or signaling message, a control or signaling instruction, a control or signaling signal, or signaling instructions, whether proprietary or standardized, that convey information from one point to another.

Connections are used to transport user communications and other device information between the elements and devices of the telecommunication system **102**. The term "connection" as used herein means the transmission media used to carry user communications between communication devices or between the elements of the telecommunication system **102**. For example, a connection can carry a user's voice, computer data, or other communication device data.

A connection can be associated with either in-band communications or out-of-band communications.

A system of links and connections connect the elements of the telecommunication system **102**. The signaling processor **110** communicates to the first communication device **106** through a link **116**, to the service platform **112** through a link **118**, to the interworking unit **114** through a link **120**, and to the second communication device **108** through a link **122**. The interworking unit **114** communicates to the first communication device **106** through a connection **124**, to the service platform **112** through a connection **126**, and to the second communication device **108** through a connection **128**. It shall be appreciated that other links can extend from the signaling processor **110** to other systems, networks, or devices. In addition, other connections may extend from the interworking unit **114** or from the first and second communication devices **106** and **108** to other systems, networks, or devices.

Each of the first and second communication devices **106** and **108** comprises customer premises equipment, a call processing platform, a switch, or any other device capable of initiating, handling, or terminating a call, including a telephone, a computer, a facsimile machine, a private branch exchange, a service platform, or an enhanced platform that is capable of processing calls. It will be appreciated that other communication devices may be included. However, the number of communication devices shown has been restricted for clarity.

The signaling processor **110** of the service platform system **104** accepts call signaling or control messages from, and transmits call signaling or control messages to, all other elements and devices. The signaling processor **110** thereby controls call routing and call processing in the telecommunication system **102**. One embodiment of the signaling processor **110** is discussed in more detail below.

The service platform **112** provides enhanced services for the user communications received by the interworking unit **114**. The service platform **112** may have one or multiple applications to provide multiple services. Such services may include voice messaging, facsimile messaging, mail boxes, voice recognition, conference bridging, calling card, menu routing, N00 servicing such as freephone and 900 call servicing, prepay card, tone detection, and call forwarding.

The service platform **112** receives control messages from the signaling processor **110**. The control messages instruct the service platform **112** which application to use in the service platform to process the user communications. The service platform **112** processes the user communications and returns processing data results to the signaling processor **110**. In addition, the service platform **112** returns the processed user communications to the interworking unit **114** to be transported back to the first or second communication device **106** or **108**.

The interworking unit **114** interworks connections on a call-by-call basis. The interworking unit **114** may be an ATM interworking multiplexer that interworks between the ATM format and other formats while providing multiplexing and demultiplexing functions, or it may be an ATM interworking unit that interworks between different types of ATM systems and provides domain addressing. In addition, the interworking unit **114** may be a unit with domain addressing capabilities only, an ATM multiplexer that provides multiplexing and demultiplexing functions for ATM cells, or other types of interworking units.

The interworking unit **114** accepts user communications from, and transports user communications to, the first communication device **106**, the second communication device **108**, and the service platform **112**. Preferably, the interworking unit **114** is an ATM interworking multiplexer that interworks between the first communication device **106** that communicates user communications in a TDM format over a DS0, the service platform **112** that communicates user communications in the TDM format over a DS0, and the second communication device **108** that communicates user communications in the ATM format over a SONET pipe or an SDH pipe. However, it will be appreciated that the first and second communication devices **106** and **108** may be either TDM or ATM devices, and interworking can be completed between any formats. One type of interworking unit that is compatible with the present system is discussed more fully below.

The interworking unit **114** accepts control messages from, and sends control messages to, the signaling processor **110**. The interworking unit **114** uses the information gained from the signaling processor's control message to identify the required interworking assignment so that the user communications are converted between the formats that are compatible with the first communication device **106**, the second communication device **108**, and the service platform **112**.

A selected connection is designated by a selected VPI/VCI for ATM formatted transmissions, or a selected DS0 for TDM transmissions. The interworking unit **114** therefore dynamically interworks selected VPI/VCIs to selected DS0s and dynamically interworks selected DS0s to selected VPI/VCIs. Because DS0 communications are bi-directional and ATM communications are typically uni-directional, companion VPI/VCIs may be required for interworking between a DS0 and ATM.

In addition, the interworking unit **114** has a TDM interworking function which allows the interworking unit to transport the user communications between the service platform **112** and the first or second communication devices **106** or **108** without converting the user communications to another format. This can occur, for example, when the user communications that are transferred from the first or second communication device **106** or **108** are in the same format as the format usable by the service platform **112**.

Referring back to FIG. **1**, the system operates as follows. In the preferred enhanced service processing system, a call is received into the service platform **112** from a communication device, such as the second communication device **108**. The call signaling is transported from the second communication device **108** to the signaling processor **110**. The user communications are transported in ATM cells from the second communication device **108** to the interworking unit **114**.

The signaling processor **110** processes the call signaling. The signaling processor **112** reads the call characteristics such as the routing label, including the origination point code (OPC), the destination point code (DPC), the circuit identification code (CIC), or the signaling link selection (SLS). Based on the processing of the call characteristics in the call signaling, the signaling processor **110** determines what action is to be taken, which service the call requires, and, when a plurality of service platforms exist, which service platform and which application in the service platform can provide the service. The signaling processor **110** sends a processor control message to the selected service platform **112** designating the application that is to process the user communications.

In addition, based on the call signaling processing, the signaling processor **110** selects a connection **126** from the interworking unit **114** to the service platform **112** for the user communications. The signaling processor **110** sends a pro-

cessor control message to the interworking unit **114** designating the selected connection.

The interworking unit **114** receives both the user communications from the second communication device **108** and the processor control message from the signaling processor **110**. The interworking unit **114** converts the ATM cells containing the user communications to a form that is compatible with the service platform **112**. Generally, the ATM cells are converted into a TDM format. The interworking unit **114** then uses the information gained from the processor control message to route the user communications to the service platform **112** over the selected connection **126**. The selected connection **126** is generally a selected DS0.

The service platform **112** receives both the user communications from the interworking unit **114** and the processor control message from the signaling processor **110**. The service platform **112** uses the information in the processor control message to process the user communications using the selected interactive application. When the application has completed, the service platform **112** transmits the processing results to the signaling processor **110** and the processed user communications to the interworking unit **114** to be transported either back to the second communication device **108** or to another service platform or device (not shown). The processing results contain control messages and data that allows the signaling processor **110** to reroute the processed user communications to another service platform, to the second communication device **108**, or to the first communication device **106**.

If the user communications are transported to the second communication device, the user communications must be interworked to ATM cells that identify the VPI/VCI of the selected connection **128**. If, however, the user communications are transported to the first communication device **106**, the user communications do not need to be converted to ATM cells. In the present example, the user communications are transported to the first communication device **106**. The processing results and processed user communications are transported to the signaling processor **110** and the first communication device **106**, respectively, either throughout the duration of the call or at the completion of the call.

In addition to transferring the processing results, the service platform **112** also transmits a service complete signal to the signaling processor **110**. The signaling processor **110** receives the service complete signal and the processing results and processes them to determine if the processed user communications are to be transferred to a different device.

If more processing is required, the signaling processor **110** selects a connection and transmits a processor control message to the interworking unit **114** designating the new selected connection to either the second communication device **108** or to a new selected device (not shown). If the selected device is an ATM device, the interworking unit **114** converts the processed user communications which it received from the service platform **112** to ATM cells that identify the selected connection. The ATM cells would, for example, identify the VPI/VCI of the connection to the selected device. The interworking unit **114** then transmits the ATM cells over the connection to the selected device. The conversion of the user communications to ATM cells and the transmission of the ATM cells over the connection occurs dynamically in real time.

It will be appreciated that the call can be handled, initiated, or terminated by either of the first or second communication devices **106** or **108**. For example, the user communications can be transported by the first communication device **106** and received ultimately by the second communication device **108**. Alternately, the user communications can be transported from one of the first or second communication devices **106** or **108**, processed by the service processor **112**, and transported back to the same communication device **106** or **108**.

Also, it will be appreciated that, although in the above-described operation of the system the first communication device **106** was a TDM device, the service platform **112** was a TDM device, and the second communication device **108** was an ATM device, the first and second communication devices **106** and **108** and the service platform **112** can receive, transport, and handle user communications in any required format. Thus, the user communications can be processed in a system where the first communication device **106** is an ATM device, the service platform **112** is a TDM device, and the second communication device **108** is a TDM device or in a system where the first communication device **106** is an ATM device, the service platform **112** is a TDM device, and the second communication device **108** is an ATM device. In addition, the user communications can be processed in a system where the first communication device **106** is an ATM device, the service platform **112** is an ATM device, and the second communication device **108** is an ATM device or in a system where the first communication device **106** is a TDM device, the service platform **112** is an ATM device, and the second communication device **108** is a ATM device. In each of these instances, the signaling processor **110**, the service platform **112**, and the interworking unit **114** operate similarly to the operation described above. As one skilled in the art will appreciate, the interworking for the user communications will be determined according to the format of the devices.

FIG. **2** illustrates a telecommunication system **102** in which an ATM cross connect **230** is used to route calls. The cross connect **230** has a connection **232** to the second communication device **108** and a connection to the interworking unit **114**. The cross connect **230** receives ATM cells from the interworking, unit **114** over the connection **234** and directs the ATM cells to the second communication device **108** over the connection **232** therebetween. Alternatively, the cross connect **230** can route calls to another ATM system over a connection **236**.

As illustrated in the telecommunication system **102** of FIG. **3**, a service platform system **104**A may contain many elements. A first communication device **106** and a second communication device **108** interact with the service platform system **104**A. The service platform system **104**A contains a signaling processor **110** and a service platform **112**A.

In addition, the service platform system **104**A contains a service control point **336**, a service database **338**, and an interworking, multiplexer (mux) **340**. The service platform **112**A contains a host computer **342**, a first media processor **344**, and a second media processor **346**. However, a service platform can have greater or fewer media processors in addition to other devices.

Call signaling, and control messages are carried between the telecommunication system **102** devices on links. The signaling processor **110** communicates to the first communication device **106** through a link **116**, to the second communication device **108** through a link **122**, to the service control point **336** through a link **348**, to the service database **338** through a link **350**, to the interworking mux **340** through a link **352**, and to the host computer **342** through a link **354**. Preferably, the links **116**, **122**, **348**, **350**, **352**, and **354** are a LAN, SS7 links, or SS7 over ATM.

The host computer **342** communicates with the first media processor through a link **356**, to the second media processor

346 through a link **358**, and to the service database **338** through a link **360**. Preferably, links **356**, **358**, and **360** are either a LAN or a data bus.

User communications are carried between the telecommunication system **102** devices on connections. The interworking mux **340** communicates to the first communication device **106** through a connection **362**, to the second communication device **108** through a connection **364**, to the first media processor **344** through a connection **366**, and to the second media processor **346** through a connection **368**.

The service platform system **104**A can receive one or more calls and route the calls to the appropriate equipment. The signaling processor **110** accepts control messages from, and transmits control messages to, other elements and equipment. The signaling processor **110** thereby controls call routing and call processing in the telecommunication system.

The service control point (SCP) 336 contains information about the telecommunication system **102** and how to route calls through the telecommunication network. The SCP 336 is queried by the signaling processor **110** to determine how to route calls with advanced routing features such as N00 or menu routing. The signaling processor **110** may pass the information it gains from the SCP 336 to the host computer **342** in the processor control message.

The service database **338** is a logically centralized data storage device from which the signaling processor **110** or the host computer **342** can retrieve communication device data or other device data. The service database **338** has two aspects of a user or device profile. First, the service database **338** has service subscription data and processing options which denote the services to which a particular call or communication device has access. Second, the service database **338** has service data which is stored on behalf of a call or communication device. Service data includes such information as voice messages, facsimile messages, and electronic mail.

The interworking mux **340** interworks between ATM cells and other call formats while providing multiplexing and demultiplexing functions. The interworking mux **340** accepts user communications from the second communication device **108** and from the first communication device **106**. The interworking mux **340** accepts a processor control message containing signaling and control information from the signaling processor **110**.

The processor control message from the signaling processor **110** designates a selected connection from the interworking mux **340** to either the first media processor **344** or the second media processor **346**. In addition, a processor control message designates a selected connection from the interworking mux **340** to either the first communication device **106** or the second communication device **108**. A selected connection is designated by a selected VPI/VCI or a selected DS0. The interworking mux **340** routes the user communications over the selected connection.

User communications are communicated back and forth between the interworking mux **340** to be transported to another device and either the first media processor **344** or the second media processor **346**, or both. The interworking mux **340** uses the information gained from the signaling processor's processor control message to convert the user communications received from the second communication device **108**, for example, between ATM cells and a format that is compatible with the media processors **344** and **346**.

The media processors **344** and **346** contain applications that process the user communications. The media processors **344** and **346** perform such processing as tone detection and collection. The media processors **344** and **346** collect any information from the user communications that is required to complete an application or manipulate the user communications. The media processors **344** and **346** run applications that process voice and tones. The media processors **344** and **346** report the processing results of the processed data to the host computer **342** or to the signaling processor **110** in a media data signal. In some instances, raw data from the user communications and processed user communications are transferred to the host computer **342** for further processing.

In one embodiment, the system operates as follows where a call is initiated from the second communication device **108** and the processed user communications return to the second communication device. The host computer **342** is the service node manager that controls devices on the service node or service platform **112**A. The host computer **342** receives a processor control message from the signaling processor **110**. The processor control message instructs the host computer **342** which application to use in the media processors **344** and **346** to process the user communications. The host computer **342** controls the user communications processing in the media processors **344** and **346** and returns processed data results to the signaling processor **110** in a host computer data signal. The host computer **342** instructs the media processors **344** and **346** to return the processed user communications to the interworking mux **340** to be transported back to the second communication device **108**. The host computer **342** may also send a host control message to the signaling processor **110** with control messages such as a service complete message. It will be appreciated that other calls can be placed to and from other devices.

In another embodiment, the system operates as follows where the first communication device **106** places a call that is to be processed and returned to the first communication device. The call signaling is transported to the signaling processor **110** so that the signaling processor **110** can route the call to the appropriate device. The user communications are transported to the interworking mux **340** to be transported to an appropriate service, such as the media processors **344** and **346**. After the user communications are processed, it is transported from the media processors **344** or **346**, through the interworking mux **340**, and back to the first communication device **106**. The first communication device **106** can transmit the call in a variety of formats, including SF, ESF, ISDN, B-ISDN, and GR-303 and over a variety of transmission media including TDM, SONET, and SDH.

Referring still to FIG. **3**, the operation of the system **104**A is as follows. In the system, the signaling processor **110** controls the host computer **342** and the media processors **344** and **346** that process user communications which pass through an ATM system. The signaling processor **110** selects connections as needed to connect the devices in the telecommunication system **102**.

A call is received into the service platform system **104**A from the second communication device **108**. The call signaling is transported from the second communication device **108** to the signaling processor **110**. The user communications are transported in ATM cells from the second communication device **108** to the interworking mux **340**.

The signaling processor **110** processes the call signaling. The signaling processor **110** processes the call characteristics in the call signaling. Based on the processing of the call characteristics, the signaling processor **110** determines which service the call requires and which host computer and media processor and which application in the media processor can provide the service.

However, sometimes the call characteristics are not sufficient to determine the specific communication device that is requesting a service or to determine the specific requested service desired. This may occur, for example, when a device dials an "800" number to gain access to a calling card service. In such a situation, a service application may require a personal identification code before access to a service is provided. The signaling processor **110** then may invoke applications in the signaling processor **110** or in the media processor **344** that can interact with the call to determine the device identity or desired service.

In addition, the signaling processor **110** may query the SCP 336 or the service database **338**. This would allow the signaling processor **110** to gain service options, service data, and routing information for the call to determine the required combination of signal processing, database, and connection providing elements to provide a service.

The call signaling is processed and the signaling processor **110** determines the resource needed to process the service request. The signaling processor **110** then sends a processor control message to the selected host computer **342** designating the application that is to process the user communications. In addition, based on the processed call signaling, the signaling processor **110** selects a connection from the interworking mux **340** to the media processor **344** selected to process the user communications. The signaling processor **110** sends a processor control message to the interworking mux **340** designating the selected connection **366** and instructing the interworking mux **340** to dynamically connect the call in real time to a service platform **112A** on the connection **366** and to convert the user communications in the interworking mux **340** from the ATM cells to a format that is compatible with the selected media processor **344**.

The interworking mux **340** receives both the user communications from the second communication device **108** and the processor control message from the signaling processor **110**. The interworking mux **340** converts the ATM cells containing the user communications to a form that is compatible with the selected media processor **344**. Generally, the ATM cells are converted into a TDM format. The interworking mux **340** then uses the information gained from the processor control message to route the user communications to the selected media processor **344** over the selected connection **366**.

The user communications are received in the selected media processor **344**. In addition, the host computer **342** transmits a host control message to the media processor **344** instructing the media processor **344** which application to use and providing other control messaging to control the processing of the user communications. The media processor **344** processes the user communications in accordance with the control messages from the host computer **342**. The media processor **344** then reports the processing results to the host computer **342** in a media processor signal over the link **354**. In addition, the media processor **344** transmits the processed user communications to the interworking mux **340**.

The host computer **342** can further service the processing results. The host computer **342** transfers the processing results, with or without further servicing, to the signaling processor **110** in a host control message. The host control message may request that the host computer **342** and the associated media processor **344** be released because processing is complete or it can request another service or media processor. When the signaling processor **110** receives the host control message, it may direct the interworking mux **340** to transfer the processed user communications to the second communication device **108** or to the first communication device **106**. In addition, the signaling processor **110** may direct the interworking mux **340** to transfer the processed user communications to another service platform or another media processor on the same service platform **112A**. If the processing is complete, the interworking mux **340** will be instructed by the signaling processor **110** to release the connection to the media processor **344**, at which point the connection will be released.

FIG. **4** illustrates the message transmissions for the user communications processing and the control messages that take place between the various telecommunication network devices to process a call. The message sequences illustrate the method for connecting a call through an ATM system to a service platform.

With reference to FIG. **3** and FIG. **4**, a communication device **108** transmits a call, including call signaling and user communications. The call signaling is received in the signaling processor **110**, and the user communications are transported to an interworking mux **340** upon a connection that was seized by the second communication device **108**.

The signaling processor **110** processes the call signaling to determine which application and service platform is required to process the user communications. The signaling processor **110** selects a connection to the selected service platform **112A**. The signaling processor **110** transmits a processor control message to the service platform **112A** requesting service for the user communications. The service request designates the application that will process the user communications and designates the connection between the service platform **112A** and the interworking mux **340** upon which the user communications will be transported.

In addition, the signaling processor **110** transmits a processor control message to the interworking mux **340** designating the selected connection assignment to the selected service platform **112A**. When the service platform **112A** is connected to the interworking mux **340** by a DS level transmission line, the connection assignment is a TDM port number, such as a DS0 port designation or an E0 port designation.

The interworking mux **340** connects to the service platform **112A** on the selected connection. When the service platform **112A** is in a TDM system and the second communication device **108** is in an ATM system and is transmitting the user communications in ATM cells, the interworking mux **340** interworks the VPI/VCI of the connection from which the ATM cells are being received to the DS0 or E0 of the connection to the service platform **112A**. When, however, processed user communications are being transported from the service platform **112A** to the interworking mux **340**, the interworking mux interworks the DS0 or E0 of the connection from which the processed user communications are being received from the service platform **112A** to the VPI/VCI of the selected connection to the second communication device **108** or other selected communication device **108**. The VPI/VCI of the selected connection back to the second communication device **108** or to some other selected communication device is designated in a processor control message. The second communication device **108** and the service platform **112A** may interact, thereby transmitting user communications to each other through the interworking mux **340** over the selected connection.

The interworking mux **340** interworks the user communications transmission between the format of the second communication device **108** and a format compatible with the service platform **112A**. In the preferred method, the user communications are converted from ATM cells received

from the second communication device **108** to a TDM format that is transported over a DS0 or E0 to the service platform **112**A. In the reverse direction, processed user communications received from the service platform **112**A over the DS0 or E0 in the TDM format are converted to ATM cells that identify the VPI/VCI for the connection to the second communication device **108**, or to some other selected device. The selected connection designations for both the second communication device **108** and the service platform **112**A are received in the interworking mux **340** from the signaling processor **110**.

When the processing of the user communications is completed by the service platform **112**A, it transmits to the signaling processor **110** a control message having a service complete message. Upon receiving the control message, the signaling processor **110** sends a processor control message to the interworking mux **340** requesting that the connection be terminated and to the second communication device **108** requesting that the connection be released. In response to the processor control message, the connections are disconnected.

With reference to FIG. **3** and FIG. **5**, after a connection has been made and the user communications have been processed in a first media processor, the signaling processor **110** may determine that further processing is required and select an application in the second media processor **346** to further process the user communications. The signaling processor **110** would transmit a second processor control message to the interworking mux **340** designating a second selected connection **368** to the second media processor **346**.

In response to the second processor control message, the interworking mux **340** disassociates the connection to the first media processor **344** and makes the second selected connection to the second media processor **346**. Then, the interworking mux **340** transmits the user communications to the second media processor **346** over the second selected connection.

In addition, the signaling processor transmits another processor control message to the host computer **342** designating a selected application in the second media processor **346** to process the user communications. In response to the processor control message, the host computer **342** transmits a host control message to the second media processor **346** to control processing of the user communications and reporting of the processing results.

FIG. **5** illustrates the message transmissions that take place between the various telecommunication system **102** devices to further process user communications in a second media processor **346**. The message sequences illustrate the method for connecting a call through an ATM system from a first media processor **344** to a second media processor **346** after a connection to the first media processor has been completed. Both media processors **344** and **346** are controlled by a single host computer **342**.

After the first connection is made by the interworking mux **340** and interaction occurs between the second communication device **108** and the first media processor **344** in the service platform **112**A (see FIG. **3**), the host computer **342** may request that further user communications processing be completed in the second media processor **346**. The host computer **342** then transmits to the signaling processor **110** a host control message containing a service complete message. Alternatively, the signaling processor **110** may initiate the processing in the second media processor **346**.

Upon receiving the host control message, the signaling processor **110** selects a connection reassignment to the second media processor **346** and transmits to the interworking mux **340** a processor control message designating the second selected connection. In a TDM system, the designation of the second selected connection to the second media processor **346** is a TDM port designation, such as a DS0 or an E0.

Upon receiving the processor control message, the interworking mux **340** disassociates the connection to the first media processor **344** and interworks the user communications with the selected connection to the second media processor **346**. The second communication device **108** and the media processor device **346** interact as described above.

When the processing of the user communications are completed by the second media processor **346**, the host computer **342** transmits to the signaling processor **110** a host control message having a service complete message. Upon receiving the host control message, the signaling processor **110** sends a processor control message to the interworking mux **340** requesting that the connection be terminated and to the second communication device **108** requesting that the connection be released. In response to the processor control message, the connections are disconnected.

FIG. **6** illustrates the message transmissions that take place between the various telecommunication system devices to further process user communications in a second service platform **602** after the user communications first has been processed by a first service platform **112**A (see FIG. **3**). The message sequences illustrate the method for connecting a call through an ATM system from a first service platform **112**A to a second service platform **602** after a connection to the first service platform has been completed.

After the initial connection is made by the interworking mux **340** and interaction occurs between the second communication device **108** and the first service platform **112**A, the first service platform **112**A may require that further user communications processing be completed in the second service platform **602**. The first service platform would transmit to the signaling processor **110** a control message having a service complete. Alternatively, the signaling processor **110** may initiate the processing in the second service platform **602**.

Upon receiving the control message, the signaling processor **110** selects a connection reassignment to the second service platform **602** and transmits a processor control message to the interworking mux **340** designating the selected connection reassignment. In a TDM system, the designation of the selected connection to the second service platform **602** is a TDM connection designation, such as a DS0 or E0 designation.

Upon receiving the processor control message, the interworking mux **340** disassociates the connection to the first service platform **112**A and interworks the user communications to the selected connection to the second service platform **602**. The second communication device **108** and second service platform **602** can then interact as described above.

When the processing of the user communications are completed by the second service platform **602**, the second service platform transmits to the signaling processor **110** a control message having a service complete message. Upon receiving the control message, the signaling processor **110** sends a processor control message to the interworking mux **340** requesting that the connection be terminated and to the second communication device **108** requesting that the connection be released. In response to the respective processor control messages, the connections are disconnected.

FIG. **7** illustrates the interaction that may take place between service platforms and communication devices

when multiple service platforms are required for call processing or when call processing is required by a communication device that does not have local access to a service platform. For example, a local communication device **702** is connected to a local service platform system **704** which contains a local signaling processor **706**, a local service platform **708**, and a local ATM interworking mux **710**.

The local communication device **702** transmits a call to the local service platform system **704** for processing of the call by an inexpensive application or by an application that is used often. The call signaling is transported to the local signaling processor **706**, and the user communications are transported to the local ATM interworking mux **710**. The signaling processor **706** selects a connection to the local service platform **708** from the local ATM interworking mux **710** and transmits a processor control message to the local ATM interworking mux **710** designating the selected connection. In addition, the signaling processor transmits a processor control message to the local service platform **708** designating the application to process the user communications. The local ATM interworking mux **710** transmits the user communications to the local service platform **708** over the selected connection, and the local service platform **708** processes the user communications.

Alternatively, the local communication device **702** may transmit a call designated for a core service platform system **712**. The core service platform system **712** contains expensive applications or infrequently used applications that are shared by a plurality of communication devices and other devices in the telecommunication network. The core service platform system contains a core signaling processor **714**, a core service platform **716**, and a core ATM interworking mux **718**.

The local communication device **702** can access the core service platform system **712** by transporting call signaling to the local signaling processor **706**. The local signaling processor **706** transports the call signaling to the core signaling processor **714**.

In addition, the local communication device **702** transports user communications to the local ATM interworking mux **710**. The local ATM interworking mux **710** receives a processor control message from the local signaling processor designating a selected connection to the core ATM interworking mux **718** through an ATM cross connect system **720** and the VPI/VCI of the selected connection. The local ATM interworking mux **710** converts the user communications to ATM cells that identify the VPI/VCI of the selected connection and transmit the ATM cells to the ATM cross connect system **720**. The ATM cross connect system **720** cross connects the ATM cells to the selected connection with the VPI/VCI and routes the ATM cells to the core ATM interworking multiplexer **718**.

In addition, the core signaling processor **714** selects a connection to the core service platform **716** and transmits to the core ATM interworking mux **718** a processor control message designating the selected connection. The core ATM interworking mux **718** converts the ATM cells to user communications having a format that is compatible with the core service platform **716** and transmits the user communications over a selected connection to the core service platform **716** for processing. A processor control message from the core signaling processor **714** to the core service platform **716** designates the applications and controls to process the user communications.

In a similar fashion, a communication device **722** that does not have a local service platform can transmit a call to be processed by the core service platform system **712** or by the local service platform system **704**. The communication device **722** transmits call signaling to the communication device signaling processor **724** and user communications to the ATM interworking mux **726**. The signaling processor **724** controls transmission of the call signaling and the user communications to the appropriate system.

FIG. **8** illustrates the interaction of service platforms in a telecommunication network. In FIG. **8**, a local service platform system **802** interacts with an edge service platform system **804**. The edge platform system **804** likewise interacts with a core service platform system **806**. Any one of the service platform systems **802**, **804**, and **806** can transmit a call to any other system.

The ATM Interworking Multiplexer

FIG. **9** shows one embodiment of an ATM interworking multiplexer (mux) **902** that is suitable for the present invention, but other multiplexers that support the requirements of the invention are also applicable. The ATM interworking mux **902** has a control interface **904**, an OC-N/STS-N interface **906**, a DS3 interface **908**, a DS1 interface **910**, a DS0 interface **912**, a signal processor **914**, an ATM adaptation layer (AAL) **916**, an OC-M/STS-M interface **918**, and an ISDN/GR-303 interface **920**.

The control interface **902** accepts control messages from the signaling processor **922**. In particular, the control interface **904** identifies DS0 connections and virtual connection assignments in the control messages from the signaling processor **922**. These assignments are provided to the AAL **916** for implementation.

The OC-N/STS-N interface **906**, the DS3 interface **908**, the DS1 interface **910**, the DS0 interface **912**, and the ISDN/GR-303 interface **920** each can accept calls, including user communications, from a communication device **924**. Likewise, the OC-M/STS-M interface **918** can accept calls, including user communications, from a communication device **926**.

The OC-N/STS-N interface **906** accepts OC-N formatted communication signals and STS-N formatted communication signals and converts the communication signals from the OC-N or STS-N formats to the DS3 format. The DS3 interface **908** accepts communication signals in the DS3 format and converts the communication signals to the DS1 format. The DS3 interface **908** can accept DS3s from the OC-N/STS-N N interface **906** or from an external connection. The DS1 interface **910** accepts the communication signals in the DS1 format and converts the communication signals to the DS0 format. The DS1 interface **910** can accept DS1s from the DS3 interface **908** or from an external connection. The DS0 interface **912** accepts communication signals in the DS0 format and provides an interface to the AAL **916**. The ISDN/GR-303 interface **920** accepts communication signals in either the ISDN format or the GR-303 format and converts the communication signals to the DS0 format. In addition, each interface may transmit signals in like manner to the communication device **924**.

The OC-M/STS-M interface **918** is operational to accept ATM cells from the AAL **916** and to transmit the ATM cells over the connection to the communication device **926**. The OC-M/STS-M interface **918** may also accept ATM cells in the OC or STS format and transmit them to the AAL **916**.

The AAL **916** comprises both a convergence sublayer and a segmentation and reassembly (SAR) sublayer. The AAL **916** is operational to accept call origination device information in the DS0 format from the DS0 interface **912** and to convert the call origination device information into ATM cells. AALs are known in the art and information about AALs is provided by International Telecommunications

Union (ITU) document I.363, which is hereby incorporated fully herein by reference. An AAL for voice communication signals is described in U.S. patent application Ser. No. 08/395,745, which was filed on Feb. 28, 1995, and entitled "Cell Processing for Voice Transmission," and which is incorporated herein by reference.

The AAL **916** obtains from the control interface **904** the virtual path identifier (VPI) and the virtual channel identifier (VCI) for each DS0 for each call connection. The AAL **916** also obtains the identity of the DS0 for each call (or the DS0s for an N×64 call). The AAL **916** then transfers the call origination device information between the identified DS0 and the identified ATM virtual connection. An acknowledgment that the assignments have been implemented may be sent back to the signaling processor **922** if desired. Calls with multiple 64 Kilo-bits per second (Kbps) DSOs are known as N×64 calls. If desired, the AAL **916** can be configured to accept control messages through the control interface **904** for N×64 calls.

As discussed above, the ATM interworking mux **902** also handles calls in the opposite direction, that is, in the direction from the OC-MI/STS-M interface **918** to the DS0 interface **912**, including calls exiting from the DS1 interface **910**, the DS3 interface **908**, the OC-N/STS-N interface **906**, and the ISDN/GR-303 interface **920**. For this traffic, the VPI/VCI has been selected already and the traffic has been routed through the cross-connect (not shown). As a result, the AAL **916** only needs to identify the preassigned assigned DS0 for the selected VPI/VCI. This can be accomplished through a look-up table. In alternative embodiments, the signaling processor **922** can provide this DSO-VPI/VCI assignment through the control interface **904** to the AAL **916**.

A technique for processing VPI/VCIs is disclosed in U.S. patent application Ser. No. 08/653,852, which was filed on May 28, 1996, and entitled "Telecommunications System with a Connection Processing System," and which is incorporated herein by reference.

DS0 connections are bi-directional and ATM connections are typically uni-directional. As a result, two virtual connections in opposing directions will typically be required for each DS0. Those skilled in the art will appreciate how this can be accomplished in the context of the invention. For example, the cross-connect can be provisioned with a second set of VPI/VCIs in the opposite direction as the original set of VPI/VCIs. For each call, ATM interworking multiplexers would be configured to invoke automatically this second VPI/VCI to provide a bi-directional virtual connection to match the bi-directional DS0 on the call.

In some embodiments, it may be desirable to incorporate digital signal processing capabilities at the DS0 level. For example, in the present invention, digital signal processing is used to detect the call trigger. It may also be desired to apply echo cancellation or encryption to selected DS0 circuits. In these embodiments, a signal processor **914** would be included either separately (as shown) or as a part of the DS0 interface **912**. The signaling processor **922** would be configured to send control messages to the ATM interworking mux **902** to implement particular features on particular DS0 circuits.

FIG. **10** shows another embodiment of an ATM interworking multiplexer (mux) **1002** that is suitable for the present invention. The ATM interworking mux **1002** has a control interface **1004**, an STM-N electrical/optical (E/O) interface **1006**, an E3 interface **1008**, an E1 interface **1010**, an E0 interface **1012**, a signal processor **1014**, an ATM adaptation layer (AAL) **1016**, an STM-M electrical/optical (E/O) interface **1018**, and a digital private network signaling system (DPNSS) interface **1020**.

The control interface **1004** accepts control messages from the signaling processor **1022**. In particular, the control interface **1004** identifies E0 connections and virtual connection assignments in the control messages from the signaling processor **1022**. These assignments are provided to the AAL **1016** for implementation.

The STM-N E/O interface **1006**, the E3 interface **1008**, the E1 interface **1010**, the E0 interface **1012**, and the DPNSS interface **1020** each can accept calls, including user communications, from a second communication device **1024**. Likewise, the STM-M E/O interface **1018** can accept calls, including user communications, from a third communication device **1026**.

The STM-N E/O interface **1006** accepts STM-N electrical or optical formatted communication signals and converts the communication signals from the STM-N electrical or STM-N optical format to the E3 format. The E3 interface **1008** accepts communication signals in the E3 format and converts the communication signals to the E1 format. The E3 interface **1008** can accept E3s from the STM-N E/O interface **1006** or from an external connection. The E1 interface **1010** accepts the communication signals in the E1 format and converts the communication signals to the E0 format. The E1 interface **1010** can accept E1s from the STM-N E/O interface **1006** or the E3 interface **1008** or from an external connection. The E0 interface **1012** accepts communication signals in the E0 format and provides an interface to the AAL **1016**. The DPNSS interface **1020** accepts communication signals in the DPNSS format and converts the communication signals to the E0 format. In addition, each interface may transmit signals in a like manner to the communication device **1024**.

The STM-M E/O interface **1018** is operational to accept ATM cells from the AAL **1016** and to transmit the ATM cells over the connection to the communication device **1026**. The STM-M E/O interface **1018** may also accept ATM cells in the STM-M E/O format and transmit them to the AAL **1016**.

The AAL **1016** comprises both a convergence sublayer and a segmentation and reassembly (SAR) sublayer. The AAL **1016** is operational to accept call origination device information in the E0 format from the E0 interface **1012** and to convert the call origination device information into ATM cells.

The AAL **1016** obtains from the control interface **1004** the virtual path identifier and the virtual channel identifier for each call connection. The AAL **1016** also obtains the identity of each call. The AAL **1016** then transfers the call origination device information between the identified E0 and the identified ATM virtual connection. An acknowledgment that the assignments have been implemented may be sent back to the signaling processor **1022** if desired. If desired, the AAL **1016** can be configured to accept control messages through the control interface **1004** for N×64 calls.

As discussed above, the ATM interworking mux **1002** also handles calls in the opposite direction, that is, in the direction from the STM-M E/O interface **1018** to the E0 interface **1012**, including calls exiting from the E1 interface **1010**, the E3 interface **1008**, the STM-N E/O interface **1006**, and the DPNSS interface **1020**. For this traffic, the VPI/VCI has been selected already and the traffic has been routed through the cross-connect (not shown). As a result, the AAL **1016** only needs to identify the pre-assigned E0 for the selected VPI/VCI. This can be accomplished through a look-up table. In alternative embodiments, the signaling processor **1022** can provide this VPI/VCI assignment through the control interface **1004** to the AAL **1016**.

E0 connections are bi-directional and ATM connections typically are uni-directional. As a result, two virtual connections in opposing directions typically will be required for each E0. Those skilled in the art will appreciate how this can be accomplished in the context of the invention. For example, the cross-connect can be provisioned with a second set of VPI/VCIs in the opposite direction as the original set of VPI/VCIs. For each call, ATM interworking multiplexers would be configured to automatically invoke this second VPI/VCI to provide a bi-directional virtual connection to match the bi-directional E0 on the call.

In some instances, it may be desirable to incorporate digital signal processing capabilities at the E0 level. For example, in the present invention, digital signal processing is used to detect the call trigger. Also, it may be desirable apply echo cancellation. In these embodiments, a signal processor **1014** would be included either separately (as shown) or as a part of the E0 interface **1012**. The signaling processor **1022** would be configured to send control messages to the ATM interworking mux **1002** to implement particular features on particular circuits.

The Signaling Processor

The signaling processor is referred to as a call/connection manager (CCM), and it receives and processes telecommunications call signaling and control messages to select connections that establish communication paths for calls. In the preferred embodiment, the CCM processes SS7 signaling to select connections for a call. CCM processing is described in a U.S. Patent Application Ser. No. 08/754,349, which is entitled "Telecommunication System," which is assigned to the same assignee as this patent application, and which is incorporated herein by reference.

In addition to selecting connections, the CCM performs many other functions in the context of call processing. It not only can control routing and select the actual connections, but it can also validate callers, control echo cancelers, generate billing information, invoke intelligent network functions, access remote databases, manage traffic, and balance network loads. One skilled in the art will appreciate how the CCM described below can be adapted to operate in the above embodiments.

FIG. **11** depicts a version of the CCM. Other versions are also contemplated. In the embodiment of FIG. **11**, the CCM **1102** controls an ATM interworking multiplexer (mux) that performs interworking of DS0s and VPI/VCIs. However, the CCM may control other communications devices and connections in other embodiments.

The CCM **1102** comprises a signaling platform **1104**, a control platform **1106**, and an application platform **1108**. Each of the platforms **1104**, **1106**, and **1108** is coupled to the other platforms.

The signaling platform **1104** is externally coupled to the SS7 systems—in particular to systems having a message transfer part (MTP), an ISDN user part (ISUP), a signaling connection control part (SCCP), an intelligent network application part (INAP), and a transaction capabilities application part (TCAP). The control platform **1106** is externally coupled to a mux control, an echo control, a resource control, billing, and operations.

The signaling platform **1104** comprises MTP levels **1–3**, ISUP, TCAP, SCCP, and INAP functionality and is operational to transmit and receive the SS7 messages. The ISUP, SCCP, INAP, and TCAP functionality use MTP to transmit and receive the SS7 messages. Together, this functionality is referred as an "SS7 stack," and it is well known. The software required by one skilled in the art to configure an SS7 stack is commercially available, for example, from the Trillium company.

The control platform **1106** is comprised of various external interfaces including a mux interface, an echo interface, a resource control interface, a billing interface, and an operations interface. The mux interface exchanges messages with at least one mux. These messages comprise DS0 to VPI/VCI assignments, acknowledgments, and status information. The echo control interface exchanges messages with echo control systems. Messages exchanged with echo control systems might include instructions to enable or disable echo cancellation on particular DS0s, acknowledgments, and status information.

The resource control interface exchanges messages with external resources. Examples of such resources are devices that implement continuity testing, encryption, compression, tone detection/transmission, voice detection, and voice messaging. The messages exchanged with resources are instructions to apply the resource to particular DS0s, acknowledgments, and status information. For example, a message may instruct a continuity testing resource to provide a loopback or to send and detect a tone for a continuity test.

The billing interface transfers pertinent billing information to a billing system. Typical billing information includes the parties to the call, time points for the call, and any special features applied to the call. The operations interface allows for the configuration and control of the CCM **1102**. One skilled in the art will appreciate how to produce the software for the interfaces in the control platform **1106**.

The application platform **1108** is functional to process signaling information from the signaling platform **1104** in order to select connections. The identity of the selected connections are provided to the control platform **1106** for the mux interface. The application platform **1108** is responsible for validation, translation, routing, call control, exceptions, screening, and error handling. In addition to providing the control requirements for the mux, the application platform **1108** also provides requirements for echo control and resource control to the appropriate interface of the control platform **1106**. In addition, the application platform **1108** generates signaling information for transmission by the signaling platform **1104**. The signaling information might be ISUP, INAP, or TCAP messages to external network elements. Pertinent information for each call is stored in a call control block (CCB) for the call. The CCB can be used for tracking and billing the call.

The application platform **1108** operates in general accord with the Basic Call Model (BCM) defined by the ITU. An instance of the BCM is created to handle each call. The BCM includes an originating process and a terminating process. The application platform **1108** includes a service switching function (SSF) that is used to invoke the service control function (SCF). Typically, the SCF is contained in a service control point (SCP). The SCF is queried with TCAP or INAP messages. The originating or terminating processes will access remote databases with intelligent network (IN) functionality via the SSF function.

Software requirements for the application platform **1108** can be produced in specification and description language (SDL) defined in ITU-T Z.100. The SDL can be converted into C code. Additional C and C++ code can be added as required to establish the environment.

The CCM **1102** can be comprised of the above-described software loaded onto a computer. The computer can be an Integrated Micro Products (IMP) FT-Sparc 600 using the Solaris operating system and conventional database systems. It may be desirable to utilize the multi-threading capability of a Unix operating system.

From FIG. **11**, it can be seen that the application platform **1108** processes signaling information to control numerous systems and facilitate call connections and services. The SS7 signaling is exchanged with external components through the signaling platform **1104**, and control information is exchanged with external systems through the control platform **1106**. Advantageously, the CCM **1102** is not integrated into a switch CPU that is coupled to a switching matrix. Unlike an SCP, the CCM **1102** is capable of processing ISUP messages independently of TCAP queries.

SS7 Message Designations

SS7 messages are well known. Designations for various SS7 messages commonly are used. Those skilled in the art are familiar with the following message designations:

ACM—Address Complete Message
ANM—Answer Message
BLO—Blocking
BLA—Blocking Acknowledgment
CPG—Call Progress
CRG—Charge Information
CGB—Circuit Group Blocking
CGBA—Circuit Group Blocking Acknowledgment
GRS—Circuit Group Reset
GRA—Circuit Group Reset Acknowledgment
CGU—Circuit Group Unblocking
CGUA—Circuit Group Unblocking Acknowledgment
CQM—Circuit Group Query
CQR—Circuit Group Query Response
CRM—Circuit Reservation Message
CRA—Circuit Reservation Acknowledgment
CVT—Circuit Validation Test
CVR—Circuit Validation Response
CFN—Confusion
COT—Continuity
CCR—Continuity Check Request
EXM—Exit Message
INF—Information
INR—Information Request
IAM—Initial Address
LPA—Loop Back Acknowledgment
PAM—Pass Along
REL—Release
RLC—Release Complete
RSC—Reset Circuit
RES—Resume
SUS—Suspend
UBL—Unblocking
UBA—Unblocking Acknowledgment
UCIC—Unequipped Circuit Identification Code.

CCM Tables

Call processing, typically entails two aspects. First, an incoming or "originating" connection is recognized by an originating call process. For example, the initial connection that a call uses to enter a network is the originating, connection in that network. Second, an outgoing or "terminating" connection is selected by a terminating call process. For example, the terminating connection is coupled to the originating connection in order to extend the call through the network. These two aspects of call processing are referred to as the originating, side of the call and the terminating side of the call.

FIG. **12** depicts a data structure used by the application platform **1108** to execute the BCM. This is accomplished through a series of tables that point to one another in various ways. The pointers are typically comprised of next function and next index designations. The next function points to the next table, and the next index points to an entry or a range of entries in that table. The data structure has a trunk circuit table **1202**, a trunk group table **1204**, an exception table **1206**, an ANI table **1208**, a called number table **1210**, and a routing table **1212**.

The trunk circuit table **1202** contains information related to the connections. Typically, the connections are DS0 or ATM connections. Initially, the trunk circuit table **1202** is used to retrieve information about the originating connection. Later, the table is used to retrieve information about the terminating connection. When the originating connection is being processed, the trunk group number in the trunk circuit table **1202** points to the applicable trunk group for the originating connection in the trunk group table **1204**.

The trunk group table **1204** contains information related to the originating and terminating trunk groups. When the originating connection is being processed, the trunk group table **1204** provides information relevant to the trunk group for the originating connection and typically points to the exception table **1206**.

The exception table **1206** is used to identify various exception conditions related to the call that may influence the routing or other handling of the call. Typically, the exception table **1206** points to the ANI table **1208**. Although, the exception table **1206** may point directly to the trunk group table **1204**, the called number table **1210**, or the routing table **1212**.

The ANI table **1208** is used to identify any special characteristics related to the caller's number. The caller's number is commonly known as automatic number identification (ANI). The ANI table **1208** typically points to the called number table **1210**. Although, the ANI table **1208** may point directly to the trunk group table **1204** or the routing table **1212**.

The called number table **1210** is used to identify routing requirements based on the called number. This will be the case for standard telephone calls. The called number table **1210** typically points to the routing table **1212**. Although, it may point to the trunk group table **1204**.

The routing table **1212** has information relating to the routing of the call for the various connections. The routing table **1212** is entered from a pointer in either the exception table **1206**, the ANI table **1208**, or the called number table **1210**. The routing table **1212** typically points to a trunk group in the trunk group table **1204**.

When the exception table **1206**, the ANI table **1208**, the called number table **1210**, or the routing table **1212** point to the trunk group table **1204**, they effectively select the terminating trunk group. When the terminating connection is being processed, the trunk group number in the trunk group table **1204** points to the trunk group that contains the applicable terminating connection in the trunk circuit table **1204**.

The terminating trunk circuit is used to extend the call. The trunk circuit is typically a VPI/VCI or a DS0. Thus it can be seen that by migrating through the tables, a terminating connection can be selected for a call.

FIG. **13** is an overlay of FIG. **12**. The tables from FIG. **12** are present, but for clarity, their pointers have been omitted. FIG. **13** illustrates additional tables that can be accessed from the tables of FIG. **12**. These include a CCM ID table **1302**, a treatment table **1304**, a query/response table **1306**, and a message table **1308**.

The CCM ID table **1302** contains various CCM SS7 point codes. It can be accessed from the trunk group table **1204**, and it points back to the trunk group table **1204**.

The treatment table **1304** identifies various special actions to be taken in the course of call processing. This will typically result in the transmission of a release message (REL) and a cause value. The treatment table **1304** can be accessed from the trunk circuit table **1202**, the trunk group table **1204**, the exception table **1206**, the ANI table **1208**, the called number table **1210**, the routing table **1212**, and the query/response table **1306**.

The query/response table **1306** has information used to invoke the SCF. It can be accessed by the trunk group table **1204**, the exception table **1206**, the ANI table **1208**, the called number table **1210**, and the routing table **1212**. It points to the trunk group table **1204**, the exception table **1206**, the ANI table **1208**, the called number table **1210**, the routing table **1212**, and the treatment table **1304**.

The message table **1308** is used to provide instructions for messages from the termination side of the call. It can be accessed by the trunk group table **1204** and points to the trunk group table **1204**.

FIGS. **14**–**21** depict examples of the various tables described above. FIG. **14** depicts an example of the trunk circuit table. Initially, the trunk circuit table is used to access information about the originating circuit. Later in the processing, it is used to provide information about the terminating circuit. For originating circuit processing, the associated point code is used to enter the table. This is the point code of the switch or CCM associated with the originating circuit. For terminating circuit processing, the trunk group number is used to enter the table.

The table also contains the circuit identification code (CIC). The CIC identifies the circuit which is typically a DS0 or a VPI/VCI. Thus, the invention is capable of mapping the SS7 CICs to the ATM VPI/VCI. If the circuit is ATM, the virtual path (VP) and the virtual channel (VC) also can be used for identification. The group member number is a numeric code that is used for terminating circuit selection. The hardware identifier identifies the location of the hardware associated with the originating circuit. The echo canceler (EC) identification (ID) entry identifies the echo canceler for the originating circuit.

The remaining fields are dynamic in that they are filled during call processing. The echo control entry is filled based on three fields in signaling messages: the echo suppressor indicator in the IAM or CRM, the echo control device indicator in the ACM or CPM, and the information transfer capability in the IAM. This information is used to determine if echo control is required on the call. The satellite indicator is filled with the satellite indicator in the IAM or CRM. It may be used to reject a call if too many satellites are used. The circuit status indicates if the given circuit is idle, blocked, or not blocked. The circuit state indicates the current state of the circuit, for example, active or transient. The time/date indicates when the idle circuit went idle.

FIG. **15** depicts an example of the trunk group table. During origination processing, the trunk group number from the trunk circuit table is used to key into the trunk table. Glare resolution indicates how a glare situation is to be resolved. Glare is dual seizure of the same circuit. If the glare resolution entry is set to "even/odd," the network element with the higher point code controls the even circuits, and the network element with the lower point code controls the odd circuits. If the glare resolution entry is set to "all," the CCM controls all of the circuits. If the glare resolution entry is set to "none," the CCM yields. The continuity control entry lists the percent of calls requiring continuity tests on the trunk group.

The common language location identifier (CLLI) entry is a Bellcore standardized entry. The satellite trunk group entry indicates that the trunk group uses a satellite. The satellite trunk group entry is used in conjunction with the satellite indicator field described above to determine if the call has used too many satellite connections and, therefore, must be rejected. The service indicator indicates if the incoming message is from a CCM (ATM) or a switch (TDM). The outgoing message index (OMI) points to the message table so that outgoing messages can obtain parameters. The associated number plan area (NPA) entry identifies the area code.

Selection sequence indicates the methodology that will be used to select a connection. The selection sequence field designations tell the trunk group to select circuits based on the following: least idle, most idle, ascending, descending, clockwise, and counterclockwise. The hop counter is decremented from the IAM. If the hop counter is zero, the call is released. Automatic congestion control (ACC) active indicates whether or not congestion control is active. If automatic congestion control is active, the CCM may release the call. During termination processing, the next function and index are used to enter the trunk circuit table.

FIG. **16** depicts an example of the exception table. The index is used as a pointer to enter the table. The carrier selection identification (ID) parameter indicates how the caller reached the network and is used for routing certain types of calls. The following are used for this field: spare or no indication, selected carrier identification code presubscribed and input by the calling party, selected carrier identification code presubscribed and not input by the calling party, selected carrier identification code presubscribed and no indication of input by the calling party, and selected carrier identification code not presubscribed and input by the calling party. The carrier identification (ID) indicates the network that the caller wants to use. This is used to route calls directly to the desired network. The called party number nature of address differentiates between 0+ calls, 1+ calls, test calls, and international calls. For example, international calls might be routed to a pre-selected international carrier.

The called party "digits from" and "digits to" focus further processing unique to a defined range of called numbers. The "digits from" field is a decimal number ranging from 1–15 digits. It can be any length and, if filled with less than 15 digits, is filled with 0s for the remaining digits. The "digits to" field is a decimal number ranging from 1–15 digits. It can be any length and, if filled with less than 15 digits, is filled with 9s for the remaining digits. The next function and next index entries point to the next table which is typically the ANI table.

FIG. **17** depicts an example of the ANI table. The index is used to enter the fields of the table. The calling party category differentiates among types of calling parties, for example, test calls, emergency calls, and ordinary calls. The calling party\charge number entry nature of address indicates how the ANI is to be obtained. The following is the table fill that is used in this field: unknown, unique subscriber numbers, ANI not available or not provided, unique national number, ANI of the called party included, ANI of the called party not included, ANI of the called party includes national number, non-unique subscriber number, non-unique national number, non-unique international number, test line test code, and all other parameter values.

The "digits from" and "digits to" focus further processing unique to ANI within a given range. The data entry indicates

if the ANI represents a data device that does not need echo control. Originating line information (OLI) differentiates among ordinary subscriber, multiparty line, ANI failure, station level rating, special operator handling, automatic identified outward dialing, coin or non-coin call using database access, 800\888 service call, coin, prison/inmate service, intercept (blank, trouble, and regular), operator handled call, outward wide are a telecommunications service, telecommunications relay service (TRS), cellular services, private paystation, and access for private virtual network types of service. The next function and next index point to the next table which is typically the called number table.

FIG. **18** depicts an example of the called number table. The index is used to enter the table. The called number nature of address entry indicates the type of dialed number, for example, national versus international. The “digits from” and “digits to” entries focus further processing unique to a range of called numbers. The processing follows the processing logic of the “digits from” and “digits to” fields in FIG. **16**. The next function and next index point to the next table which is typically the routing table.

FIG. **19** depicts an example of the routing table. The index is used to enter the table. The transit network selection (TNS) network identification (ID) plan indicates the number of digits to use for the CIC. The transit network selection “digits from” and “digits to” fields define the range of numbers to identify an international carrier. The circuit code indicates the need for an operator on the call. The next function and next index entries in the routing table are used to identify a trunk group. The second and third next function/index entries define alternate routes. The third next function entry can also point back to another set of next functions in the routing table in order to expand the number of alternate route choices. The only other entries allowed are pointers to the treatment table. If the routing table points to the trunk group table, then the trunk group table typically points to a trunk circuit in the trunk circuit table. The yield from the trunk circuit table is the terminating connection for the call.

It can be seen from FIGS. **14–19** that the tables can be configured and relate to one another in such a way that call processes can enter the trunk circuit table for the originating connection and can traverse through the tables by keying on information and using pointers. The yield of the tables is typically a terminating connection identified by the trunk circuit table. In some cases, treatment is specified by the treatment table instead of a connection. If, at any point during the processing, a trunk group can be selected, processing may proceed directly to the trunk group table for terminating circuit selection. For example, it may be desirable to route calls from a particular ANI over a particular set of trunk groups. In this case, the ANI table would point directly to the trunk group table, and the trunk group table would point to the trunk circuit table for a terminating circuit. The default path through the tables is: trunk circuit, trunk group, exception, ANI, called number, routing, trunk group, and trunk circuit.

FIG. **20** depicts an example of the treatment table. Either the index or the message received cause number are filled and are used to enter the table. If the index is filled and used to enter the table, the general location, coding standard, and cause value indicator are used to generate an SS7 REL. The message received cause value entry is the cause value in a received SS7 message. If the message received cause value is filled and used to enter the table, then the cause value from that message is used in a REL from the CCM. The next function and next index point to the next table.

FIG. **21** depicts an example of the message table. This table allows the CCM to alter information in outgoing messages. Message type is used to enter the table, and it represents the outgoing standard SS7 message type. The parameter is the pertinent parameter within the outgoing SS7 message. The indexes point to various entries in the trunk group table and determine if parameters can be unchanged, omitted, or modified in the outgoing messages.

Those skilled in the art will appreciate that variations from the specific embodiments disclosed above are contemplated by the invention. The invention should not be restricted to the above embodiments, but should be measured by the following claims.

What is claimed is:

1. A method for operating a communication system, the method comprising:

receiving information into a processing system wherein the information is related to a user communication in a first communication format;

in the processing system, selecting a service and a service node to provide the service based on the information;

in the processing system, generating and transmitting a first message from the processing system;

in the processing system, generating and transmitting a second message from the processing system to the service node wherein the second message indicates the selected service and a user;

receiving the user communication in the first communication format and the first message into an interworking unit; and

in the interworking unit, converting the user communication from the first communication format to a second communication format and transmitting the user communication in the second communication format to the service node in response to the first message.

2. The method of claim **1** wherein the information is a telecommunication signaling message.

3. The method of claim **1** wherein the information is a Signaling System #7 message.

4. The method of claim **1** wherein the information is a Signaling System #7 Initial Address Message (IAM).

5. The method of claim **1** wherein the information is an internet message.

6. The method of claim **1** wherein the information is an ethernet message.

7. The method of claim **1** wherein the first communication format is a time division multiplex communication format.

8. The method of claim **1** wherein the first communication format is an asynchronous transfer mode communication format.

9. The method of claim **1** wherein the first communication format is a connectionless communication format.

10. The method of claim **1** wherein the second communication format is a time division multiplex communication format.

11. The method of claim **1** wherein the second communication format is an asynchronous transfer mode communication format.

12. The method of claim **1** wherein the second communication format is a connectionless communication format.

13. The method of claim **1** further comprising:

receiving the user communication in the second communication format and the second message into the service node; and

in the service node, providing the service in response to the second message.

14. The method of claim 13 wherein the service includes voice message processing.

15. The method of claim 13 wherein the service includes facsimile call processing.

16. The method of claim 13 wherein the service includes voice recognition processing.

17. The method of claim 13 wherein the service includes conference call processing.

18. The method of claim 13 wherein the service includes calling card call processing.

19. The method of claim 13 wherein the service includes toll free call processing.

20. The method of claim 13 wherein the service includes menu routing call processing.

21. The method of claim 13 wherein the service includes tone detection processing.

22. The method of claim 13 further comprising:

in the service node, generating and transmitting a third message from the service node indicating that the service has been provided;

receiving the third message into the processing system;

in the processing system, generating and transmitting a fourth message from the processing system in response to the third message;

receiving the fourth message into the interworking unit; and

in the interworking unit, stopping transmission of the user communication to the service node in response to the fourth message.

23. The method of claim 13 further comprising:

in the service node, generating and transmitting a third message from the service node indicating that the service has been provided;

receiving the third message into the processing system;

in the processing system, generating and transmitting a fourth message from the processing system in response to the third message;

receiving the fourth message into the interworking unit; and

in the interworking unit, transmitting the user communication to another destination in response to the fourth message.

24. The method of claim 13 further comprising:

in the service node, generating and transmitting a third message from the service node indicating that the service has been provided;

receiving the third message into the processing system;

in the processing system, selecting another service and another service node to provide the other service in response to the third message;

in the processing system, generating and transmitting a fourth message and a fifth message from the processing system;

receiving the fourth message into the interworking unit; and

in the interworking unit, transmitting the user communication to the other service node to provide the other service in response to the fourth message.

25. The method of claim 24 further comprising:

receiving the user communication and the fifth message into the other service node; and

in the other service node, providing the other service in response to the fifth message.

26. The method of claim 1 wherein selecting the service comprises:

generating and transmitting a database query from the processing system;

receiving a response from the database into the processing system; and

processing the response in the processing system.

27. The method of claim 1 further comprising generating billing information in the processing system.

28. The method of claim 1 further comprising validating the user communication in the processing system.

29. A communication system comprising:

a processing system configured to receive information related to a user communication in a first communication format, select a service and service node to provide the service based on the information, generate and transmit a first message and generate and transmit a second message to the service node wherein the second message indicates the selected service and a user;

an interworking unit configured to receive the first message and the user communication in the first communication format, convert the user communication from the first communication format to the second communication format in response to the first message, and transmit the user communication in the second communication format to the service node; and

a communications link configured to couple the processing system to the interworking unit.

30. The communication system of claim 29 wherein the information is a telecommunication signaling message.

31. The communication system of claim 29 wherein the information is a Signaling System #7 message.

32. The communication system of claim 29 wherein the information is a Signaling System #7 Initial Address Message (IAM).

33. The communication system of claim 29 wherein the information is an internet message.

34. The communication system of claim 29 wherein the information is an ethernet message.

35. The communication system of claim 29 wherein the first communication format is a time division multiplex communication format.

36. The communication system of claim 29 wherein the first communication format is an asynchronous transfer mode communication format.

37. The communication system of claim 29 wherein the first communication format is a connectionless communication format.

38. The communication system of claim 29 wherein the second communication format is a time division multiplex communication format.

39. The communication system of claim 29 wherein the second communication format is an asynchronous transfer mode communication format.

40. The communication system of claim 29 wherein the second communication format is a connectionless communication format.

41. The communication system of claim 29 wherein the communication system further comprises:

a service node configured to receive the user communication in the second communication format, to receive the second message, and to provide the service in response to the second message;

a communications link configured to couple the processing system and the service node; and

a communications connection configured to couple the interworking unit and the service node.

42. The communication system of claim 41 wherein the service includes voice message processing.

43. The communication system of claim **41** wherein the service includes facsimile call processing.

44. The communication system of claim **41** wherein the service includes voice recognition processing.

45. The communication system of claim **41** wherein the service includes conference call processing.

46. The communication system of claim **41** wherein the service includes calling card call processing.

47. The communication system of claim **41** wherein the service includes toll free call processing.

48. The communication system of claim **41** wherein the service includes menu routing call processing.

49. The communication system of claim **41** wherein the service includes tone detection processing.

50. The communication system of claim **41** wherein:

the service node is further configured to generate and transmit a third message indicating that the service has been provided;

the proccssing system is further configured to receive the third message and generate and transmit a fourth message based on the third message; and

the interworking unit is further configured to receive the fourth message and stop transmission of the user communication to the service node in response to the fourth message.

51. The communication system of claim **41** wherein:

the service node is further configured to generate and transmit a third message indicating that the service has been provided;

the processing system is further configured to receive the third message and generate and transmit a fourth message based on the third message; and

the interworking unit is further configured to receive the fourth message and transmit the user communication to another destination in response to the fourth message.

52. The communication system of claim **41** wherein:

the service node is further configured to generate and transmit a third message indicating that the service has been provided;

the processing system is further configured to receive the third message, select another service and another service node to provide the other service in response to the third message, to generate and transmit a fourth message and a fifth message; and

the interworking unit is further configured to receive the fourth message and transmit the user communication to the other service node to provide the other service in response to the fourth message.

53. The communication system of claim **52** wherein the other service node is further configured to receive the user communication and the fifth message and to provide the other service in response to the fifth message.

54. The communication system of claim **29** wherein the processing system is further configured to generate and transmit a query to a database, receive a response from the data base, and process the response to select the service and the service node to provide the service.

55. The communication system of claim **28** wherein the processing system is further configured to generate billing information.

56. The communication system of claim **29** wherein the processing system is further configured to validate the user communication.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 6,330,224 B1
DATED : December 11, 2001
INVENTOR(S) : Christie et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Title page,
Item [73], Assignee:
Sprint Communications Company, L.P.

Signed and Sealed this

Twenty-first Day of May, 2002

Attest:

JAMES E. ROGAN
Director of the United States Patent and Trademark Office

Attesting Officer

EXHIBIT H

US006697340B2

(12) **United States Patent**
Christie et al.

(10) **Patent No.: US 6,697,340 B2**
(45) **Date of Patent: Feb. 24, 2004**

(54) **SYSTEM AND METHOD FOR PROVIDING ENHANCED SERVICES FOR A TELECOMMUNICATION CALL**

(75) Inventors: **Joseph Michael Christie**, deceased, late of San Bruno, CA (US); by Joseph S. Christie, legal representative, Mt. Pleasant, PA (US); by Jean M. Christie, legal representative, Mt. Pleasant, PA (US); **Tracy Lee Nelson**, Shawnee Mission, KS (US)

(73) Assignee: **Sprint Communications Company L.P.**, Overland Park, KS (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **10/336,999**

(22) Filed: **Jan. 6, 2003**

(65) **Prior Publication Data**

US 2003/0148783 A1 Aug. 7, 2003

(Under 37 CFR 1.47)

Related U.S. Application Data

(63) Continuation of application No. 09/272,932, filed on Mar. 18, 1999, now Pat. No. 6,535,483, which is a continuation of application No. 08/754,847, filed on Nov. 22, 1996, now Pat. No. 5,920,562.

(51) **Int. Cl.**^{7} **H04L 12/16**
(52) **U.S. Cl.** **370/259**; 370/351; 379/67.1
(58) **Field of Search** 370/259, 260–5, 370/351–3, 355–6, 389, 395.1, 397, 399, 395.2, 395.3, 464–7, 475; 379/67.1, 68, 85, 88.01, 88.09, 88.16, 88.17, 88.18, 88.19, 88.22, 88.25, 88.26, 93.01, 142.07, 142.18, 157, 158, 201.01, 202.01, 203.01, 204.01, 207.01, 220.01, 221.14

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,375,124 A		12/1994	D'Ambrogio et al.	
5,533,108 A	*	7/1996	Harris et al.	379/211.02
5,557,667 A	*	9/1996	Bruno et al.	379/211.04
5,703,876 A	*	12/1997	Christie	370/395.61
5,892,820 A	*	4/1999	Armstrong et al.	379/213.01
6,002,689 A	*	12/1999	Christie et al.	370/401
6,031,840 A	*	2/2000	Christie et al.	370/410
6,081,529 A	*	6/2000	Christie	370/395.2
6,173,051 B1	*	1/2001	Lipchock et al.	379/220.01
6,411,624 B1	*	6/2002	Christie et al.	370/395.31

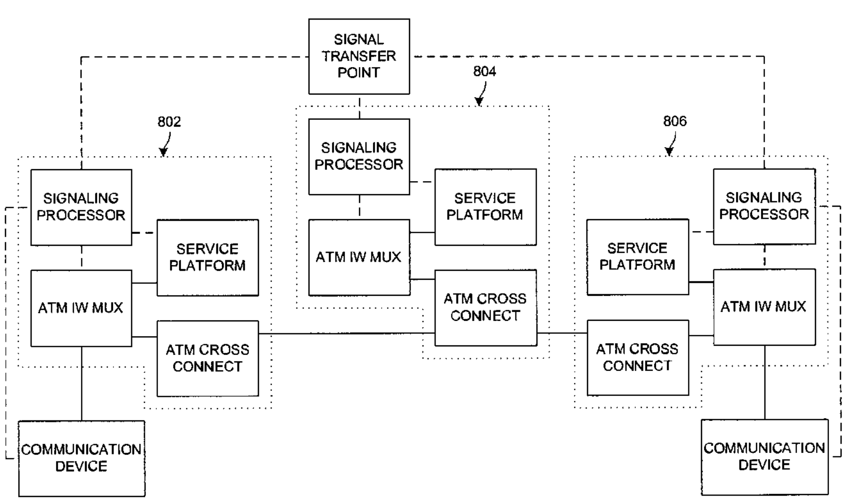
* cited by examiner

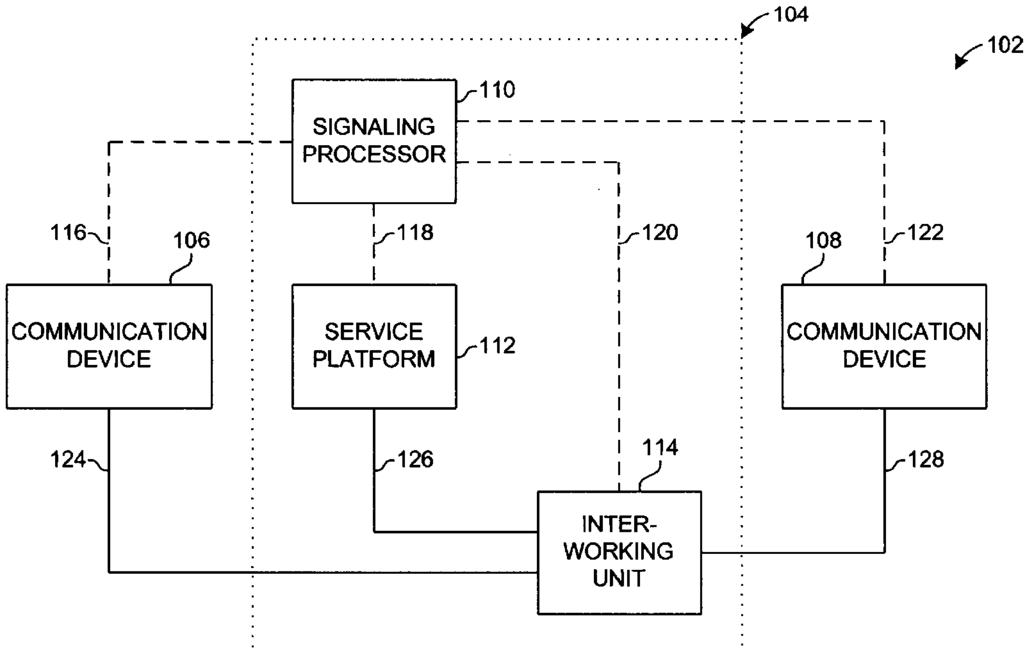
Primary Examiner—David Vincent

(57) **ABSTRACT**

A system and method provide enhanced services for a call that is transported from a communication device through an asynchronous transfer mode system. The call has user communications in asynchronous transfer mode cells and call signaling. A signaling processor receives the call signaling and processes the call signaling to determine a connection to a service platform. The signaling processor transports a processor control message designating the selected connection. An asynchronous transfer mode interworking unit receives the user communications from the communication device and the processor control message from the signaling processor. The asynchronous transfer mode interworking unit converts the user communications from the asynchronous transfer mode cells to a format compatible with the service platform and dynamically transports the user communications to the service platform in real time. The service platform processes the user communications. The reverse process can also take place with the dynamic transfer, in real time, of the processed user communications back to the communication device in asynchronous transfer mode cells that identify the connection to the communication device.

20 Claims, 14 Drawing Sheets

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SIGNALING PROCESSOR
110
116
118
120
122
106
108
COMMUNICATION DEVICE
SERVICE PLATFORM
112
COMMUNICATION DEVICE
124
126
114
128
INTER-WORKING UNIT

FIG. 1

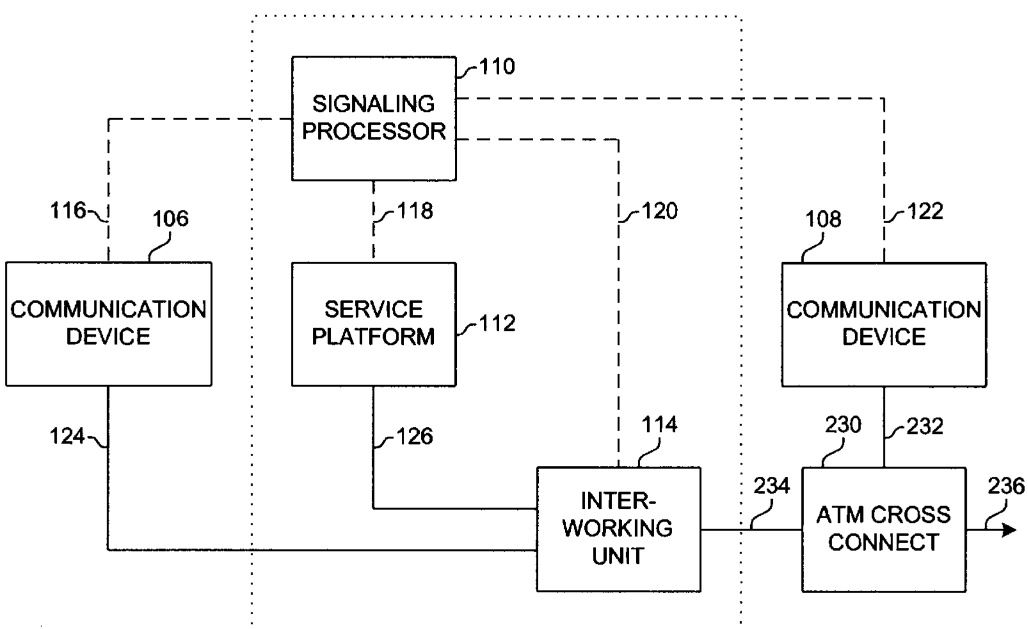

SIGNALING PROCESSOR
110
116
118
120
122
106
108
COMMUNICATION DEVICE
SERVICE PLATFORM
112
COMMUNICATION DEVICE
124
126
114
230
232
234
236
INTER-WORKING UNIT
ATM CROSS CONNECT

FIG. 2

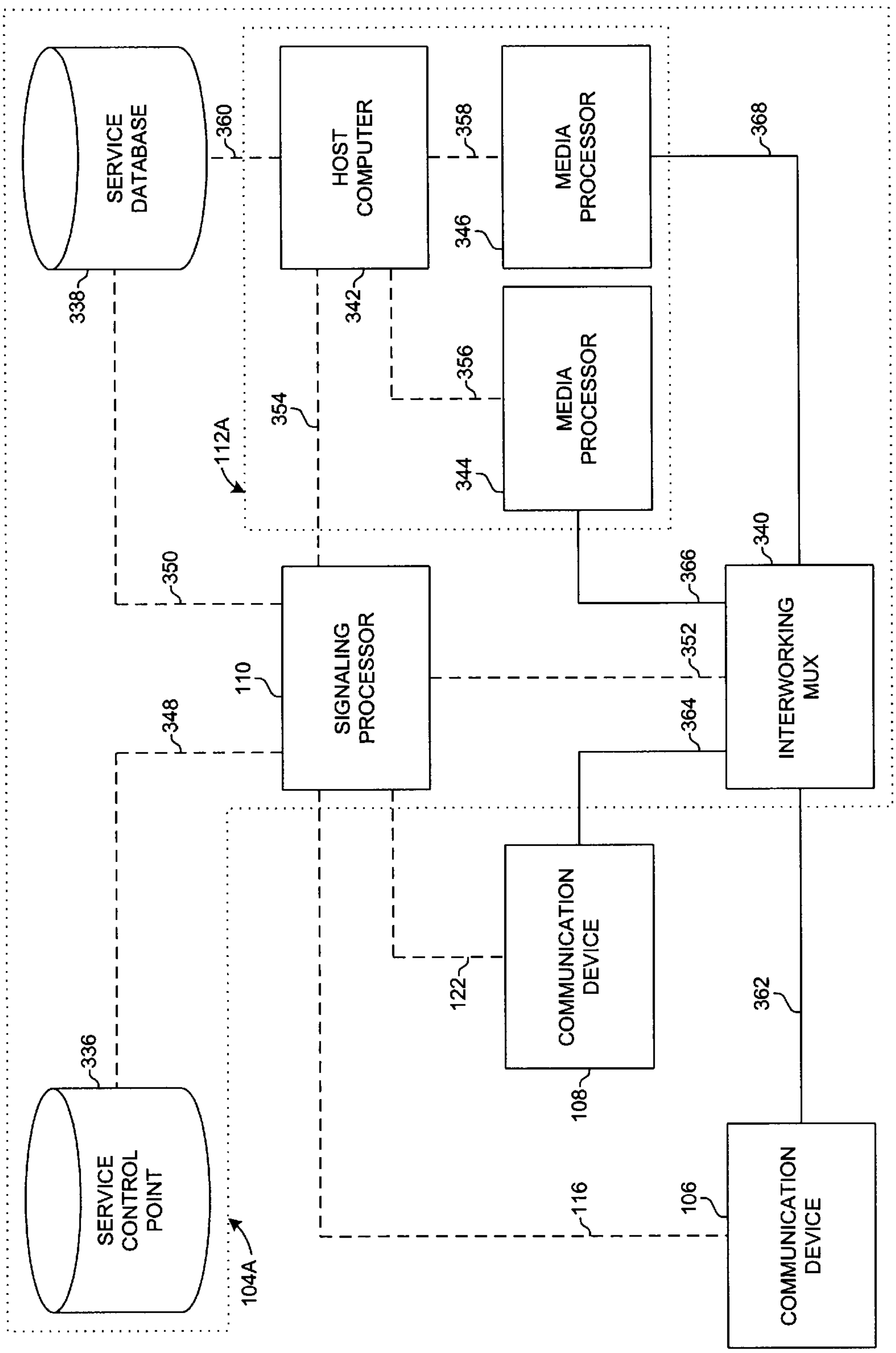
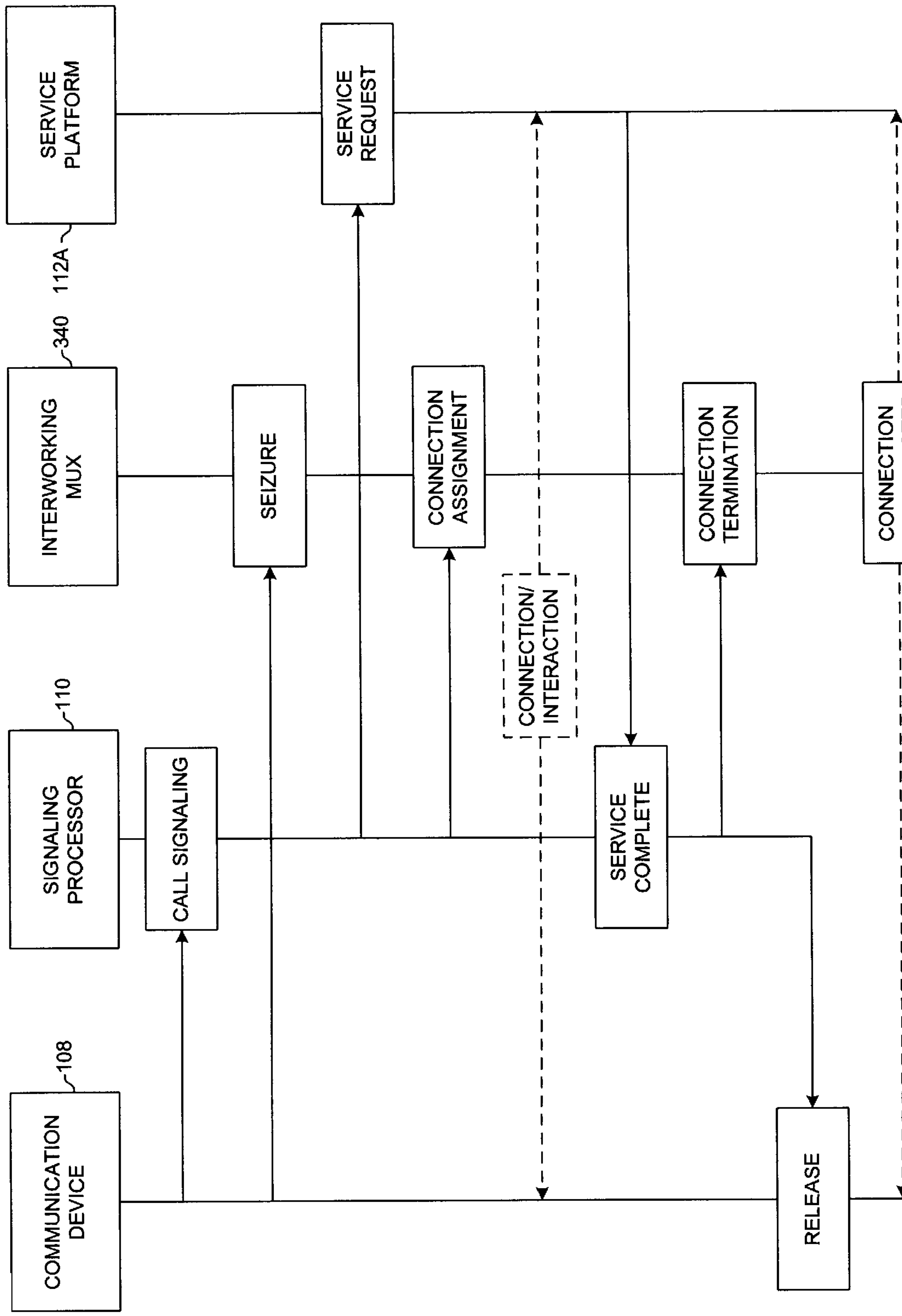
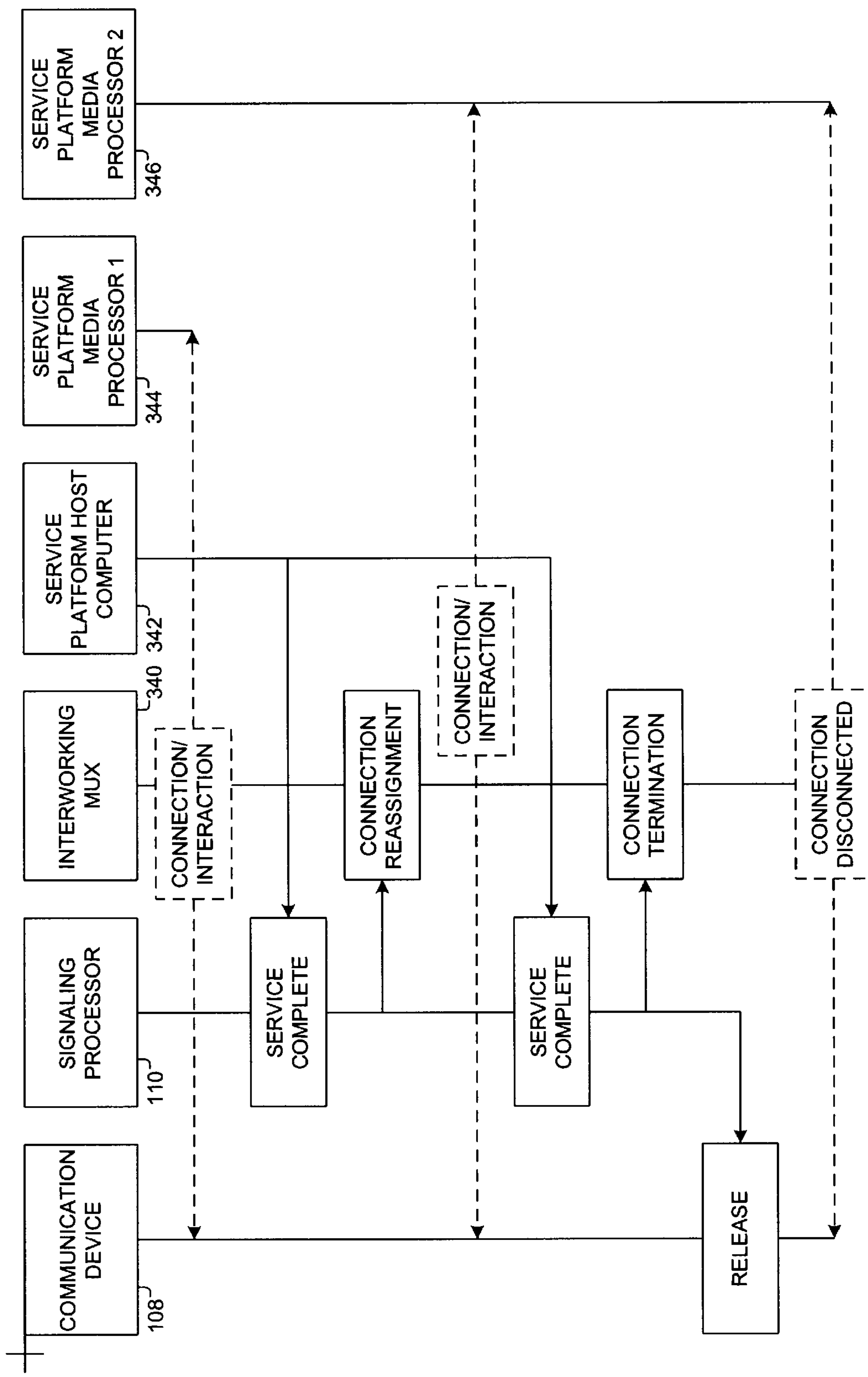

SERVICE DATABASE
338
360
HOST COMPUTER
342
358
MEDIA PROCESSOR
346
368
MEDIA PROCESSOR
344
356
354
112A
350
SIGNALING PROCESSOR
110
366
340
352
INTERWORKING MUX
364
348
COMMUNICATION DEVICE
122
108
362
SERVICE CONTROL POINT
336
104A
116
106
COMMUNICATION DEVICE
102

FIG. 3



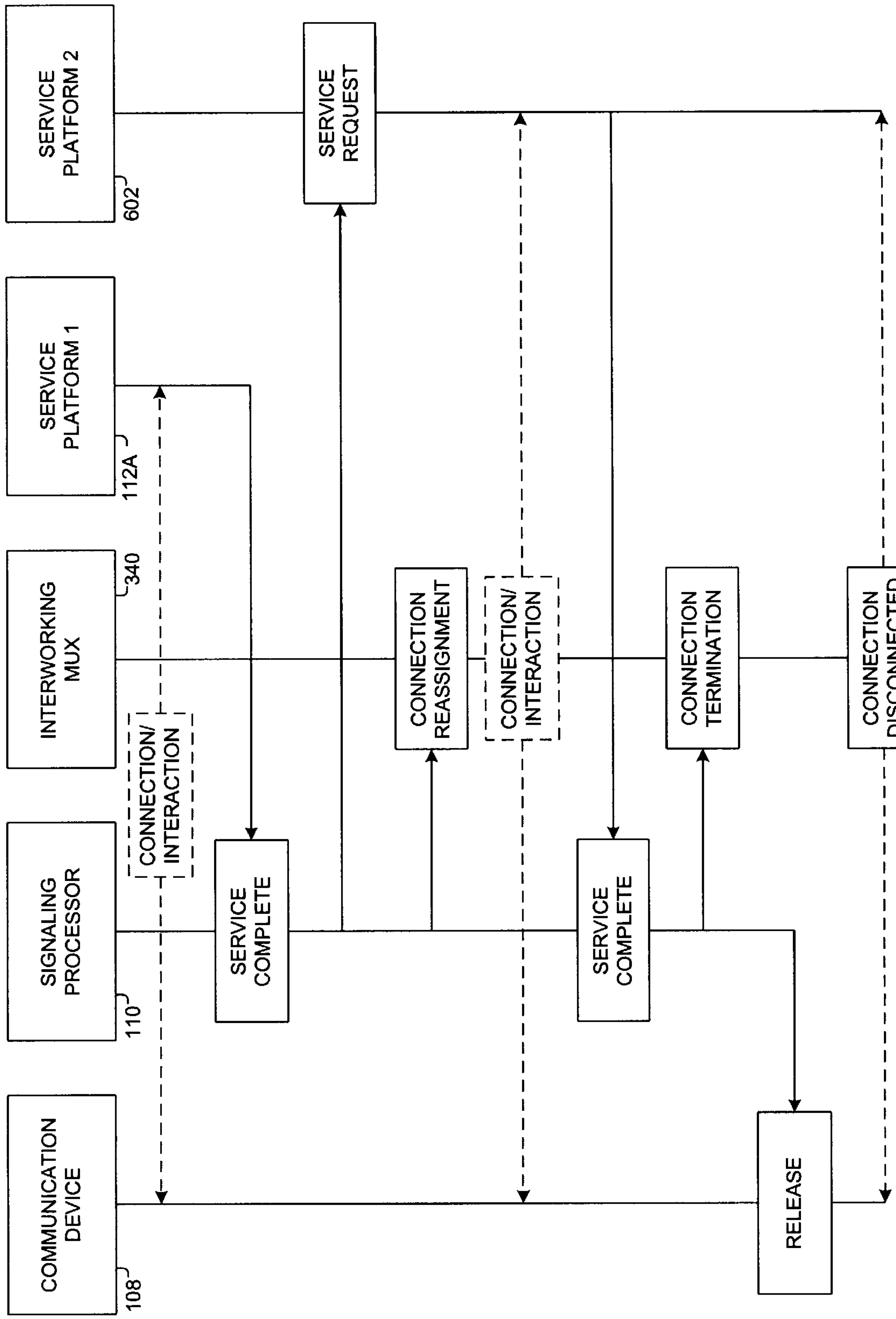
COMMUNICATION DEVICE
108
SIGNALING PROCESSOR
110
INTERWORKING MUX
340
SERVICE PLATFORM
112A
CALL SIGNALING
SEIZURE
SERVICE REQUEST
CONNECTION ASSIGNMENT
CONNECTION/ INTERACTION
SERVICE COMPLETE
CONNECTION TERMINATION
RELEASE
CONNECTION DISCONNECTED

FIG. 4



COMMUNICATION DEVICE
108
SIGNALING PROCESSOR
110
INTERWORKING MUX
340
SERVICE PLATFORM HOST COMPUTER
342
SERVICE PLATFORM MEDIA PROCESSOR 1
344
SERVICE PLATFORM MEDIA PROCESSOR 2
346
CONNECTION/ INTERACTION
SERVICE COMPLETE
CONNECTION REASSIGNMENT
CONNECTION/ INTERACTION
SERVICE COMPLETE
CONNECTION TERMINATION
RELEASE
CONNECTION DISCONNECTED

FIG. 5


SERVICE PLATFORM 2
602
SERVICE PLATFORM 1
112A
INTERWORKING MUX
340
SIGNALING PROCESSOR
110
COMMUNICATION DEVICE
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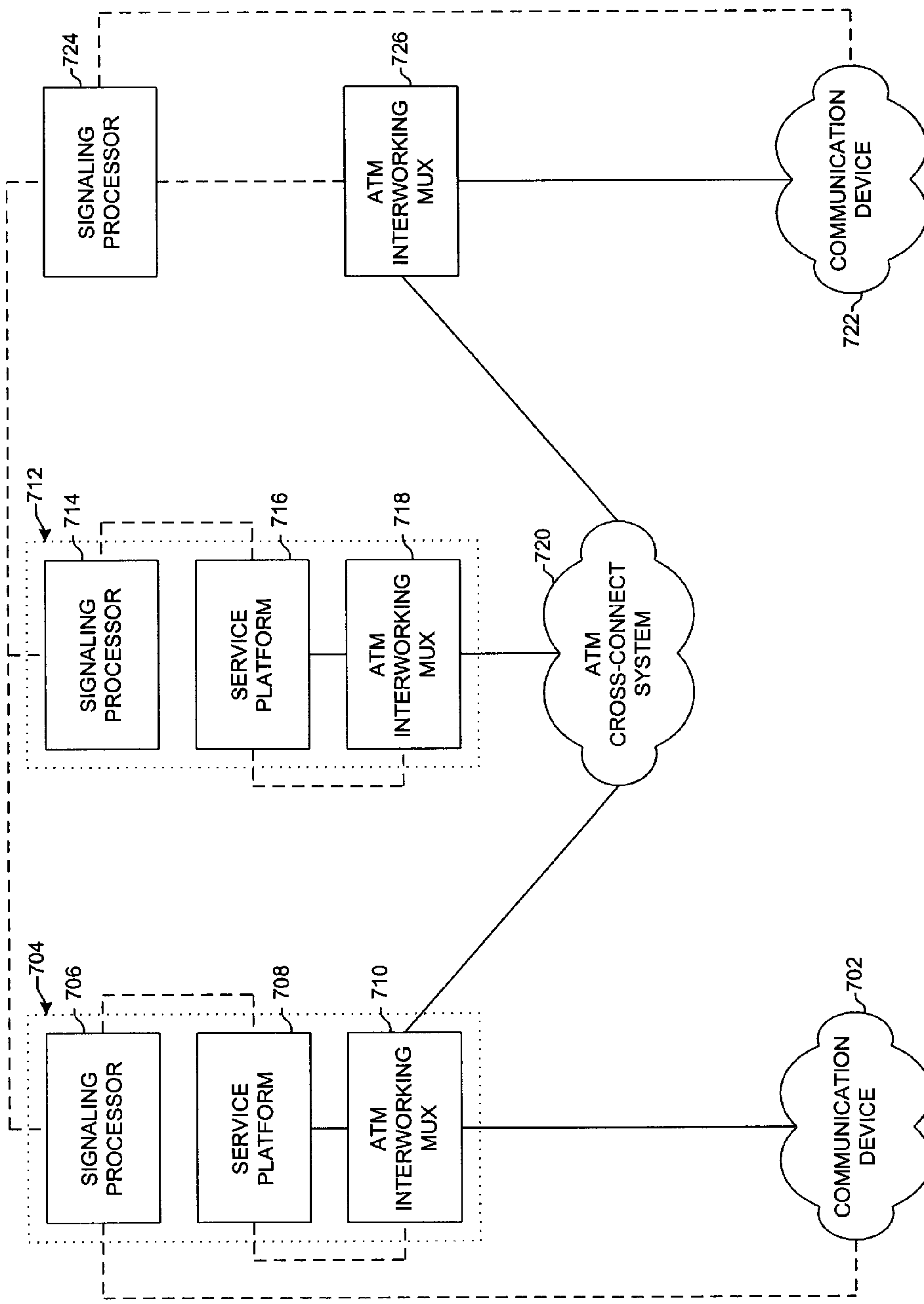
CONNECTION/ INTERACTION
SERVICE COMPLETE
SERVICE REQUEST
CONNECTION REASSIGNMENT
CONNECTION/ INTERACTION
SERVICE COMPLETE
CONNECTION TERMINATION
RELEASE
CONNECTION DISCONNECTED

FIG. 6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726
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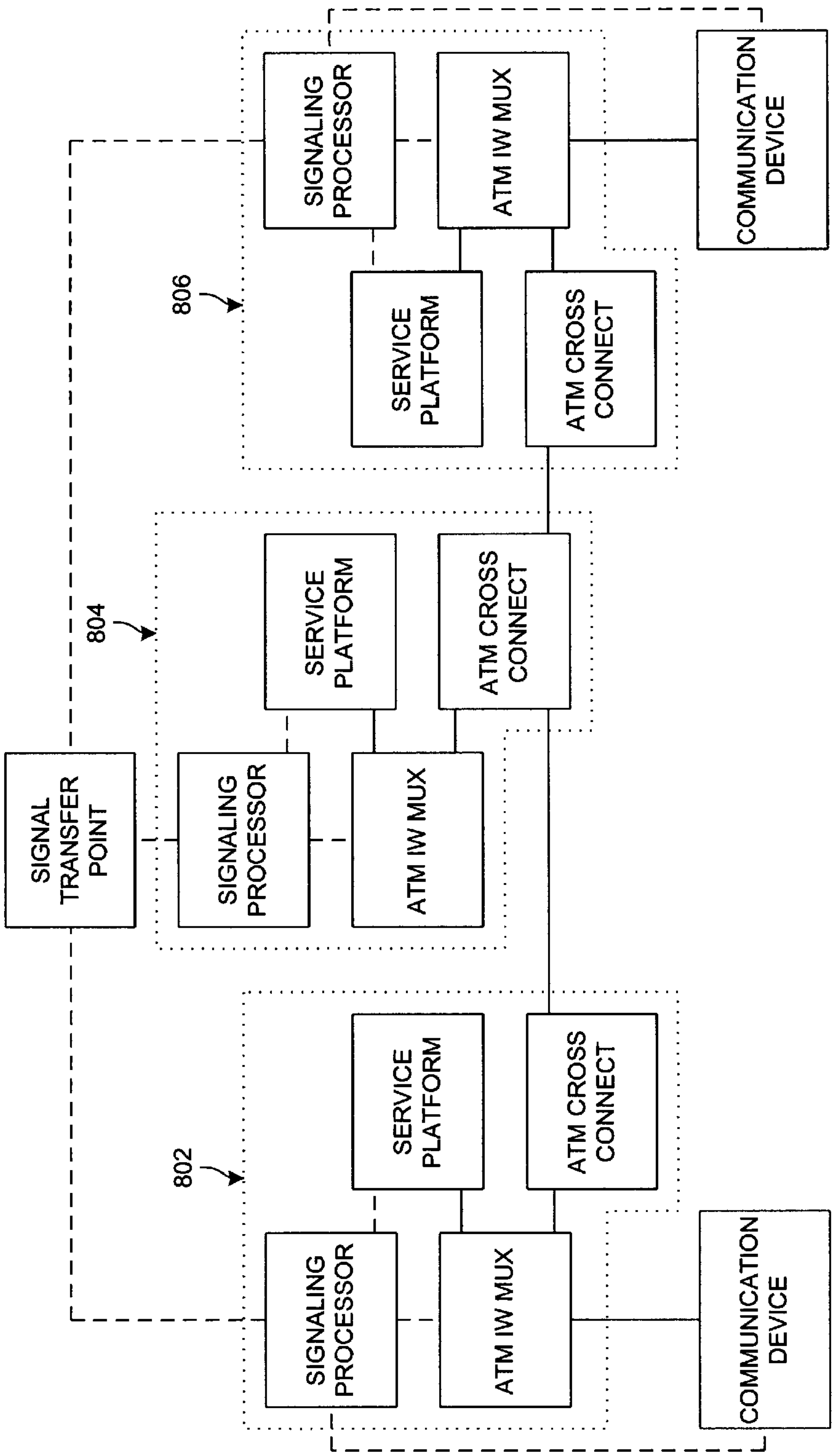
COMMUNICATION DEVICE
722
712
714
SIGNALING PROCESSOR
716
SERVICE PLATFORM
718
ATM INTERWORKING MUX
720
ATM CROSS-CONNECT SYSTEM
704
706
SIGNALING PROCESSOR
708
SERVICE PLATFORM
710
ATM INTERWORKING MUX
702
COMMUNICATION DEVICE

FIG. 7


806
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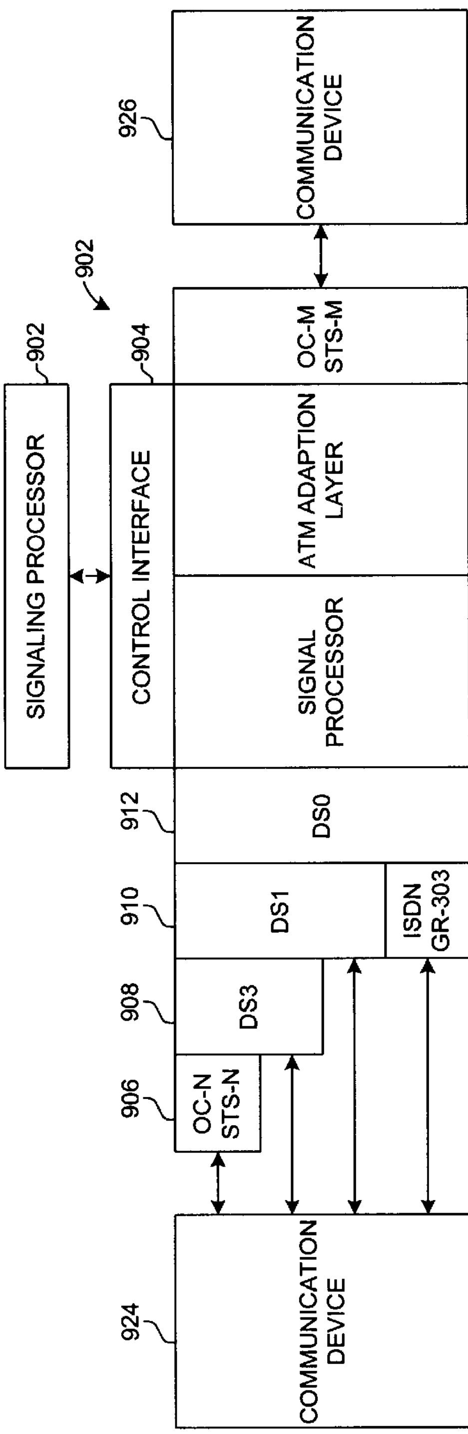
ATM IW MUX
COMMUNICATION DEVICE
SERVICE PLATFORM
ATM CROSS CONNECT
804
SERVICE PLATFORM
ATM CROSS CONNECT
SIGNAL TRANSFER POINT
SIGNALING PROCESSOR
ATM IW MUX
802
SERVICE PLATFORM
ATM CROSS CONNECT
SIGNALING PROCESSOR
ATM IW MUX
COMMUNICATION DEVICE

FIG. 8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CONTROL INTERFACE
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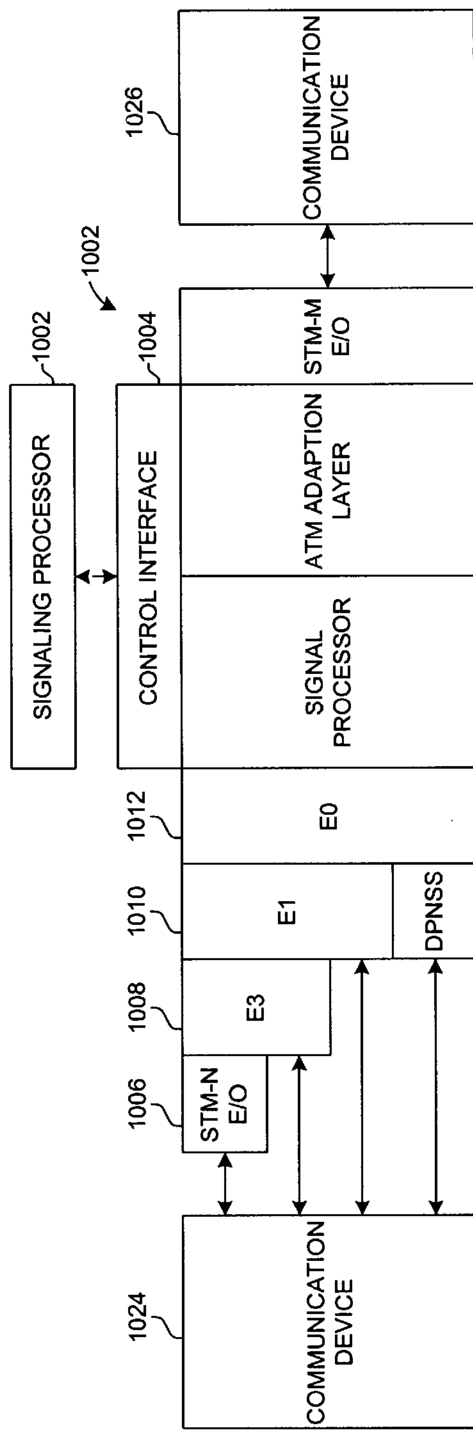
926
COMMUNICATION DEVICE
OC-M STS-M
918
ATM ADAPTION LAYER
916
SIGNAL PROCESSOR
914
912
DS0
910
DS1
ISDN GR-303
920
908
DS3
906
OC-N STS-N
924
COMMUNICATION DEVICE

FIG. 9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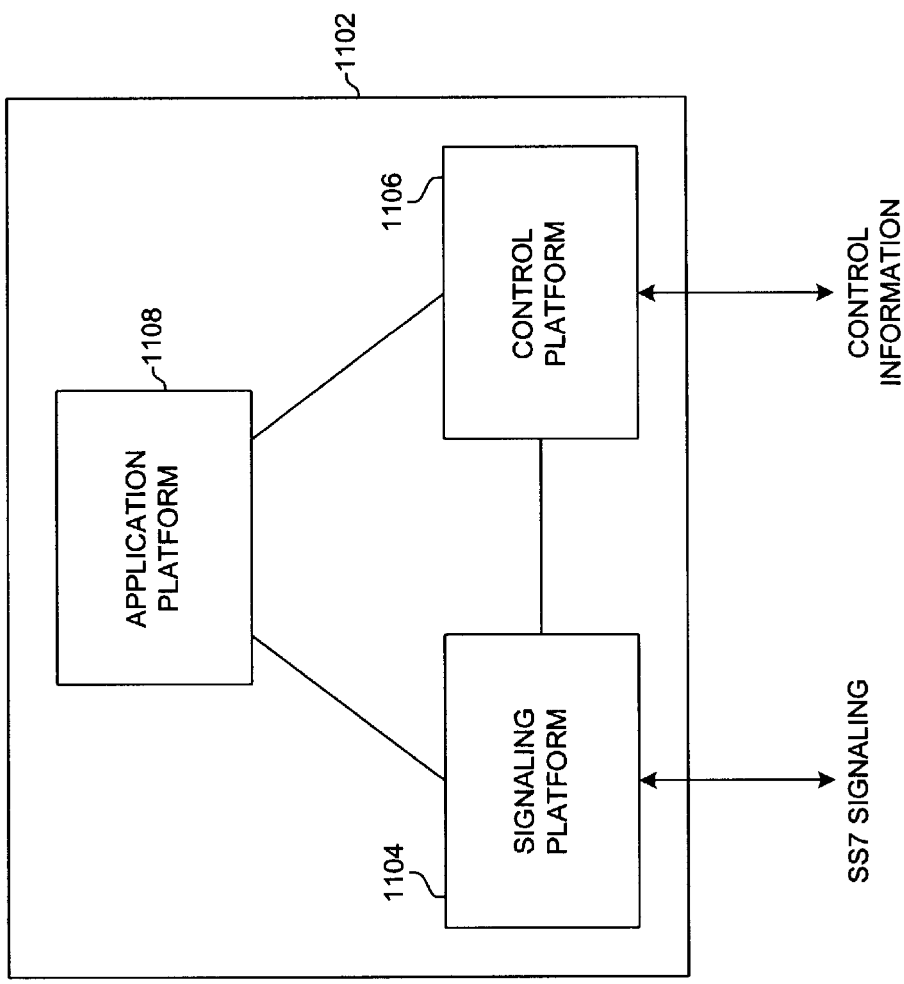
1004
CONTROL INTERFACE
1002
1026
COMMUNICATION DEVICE
STM-M E/O
1018
ATM ADAPTION LAYER
1016
SIGNAL PROCESSOR
1014
1012
E0
1010
E1
DPNSS
1020
1008
E3
1006
STM-N E/O
1024
COMMUNICATION DEVICE

FIG. 10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1106
CONTROL PLATFORM
1108
APPLICATION PLATFORM
CONTROL INFORMATION
SIGNALING PLATFORM
1104
SS7 SIGNALING

FIG. 11

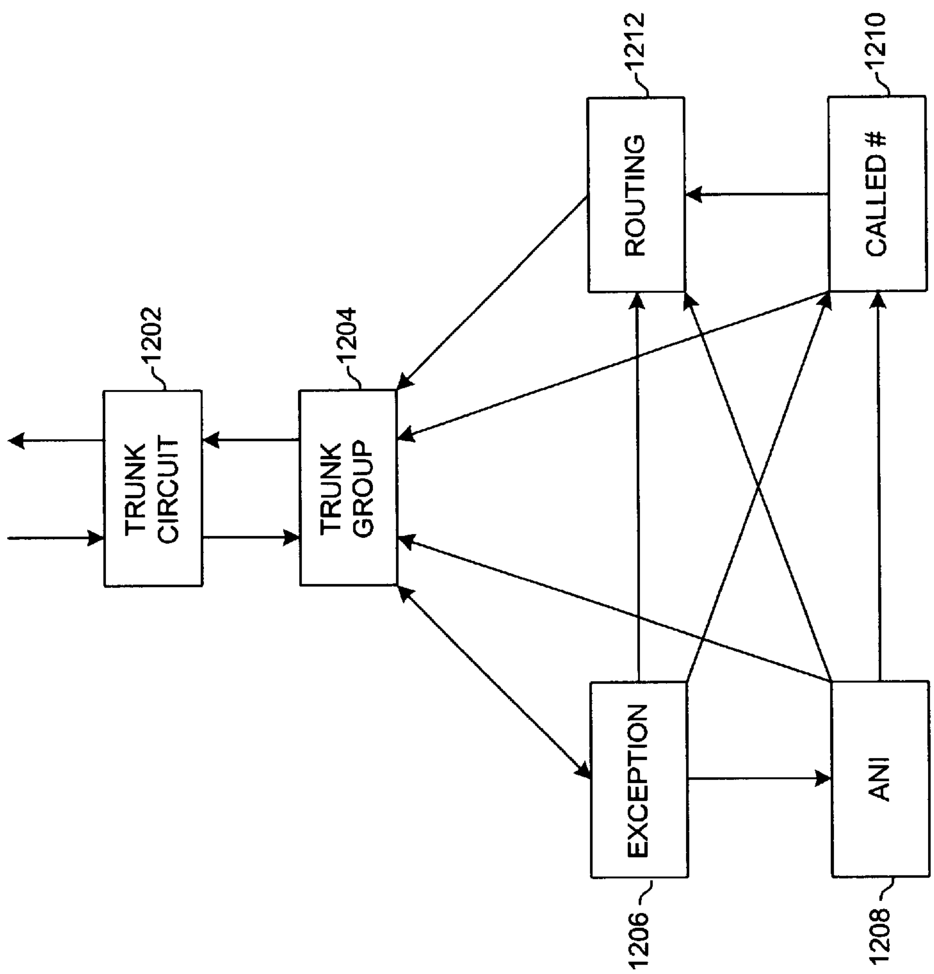
1212
ROUTING
1210
CALLED #
1202
TRUNK CIRCUIT
1204
TRUNK GROUP
EXCEPTION
1206
ANI
1208

FIG. 12

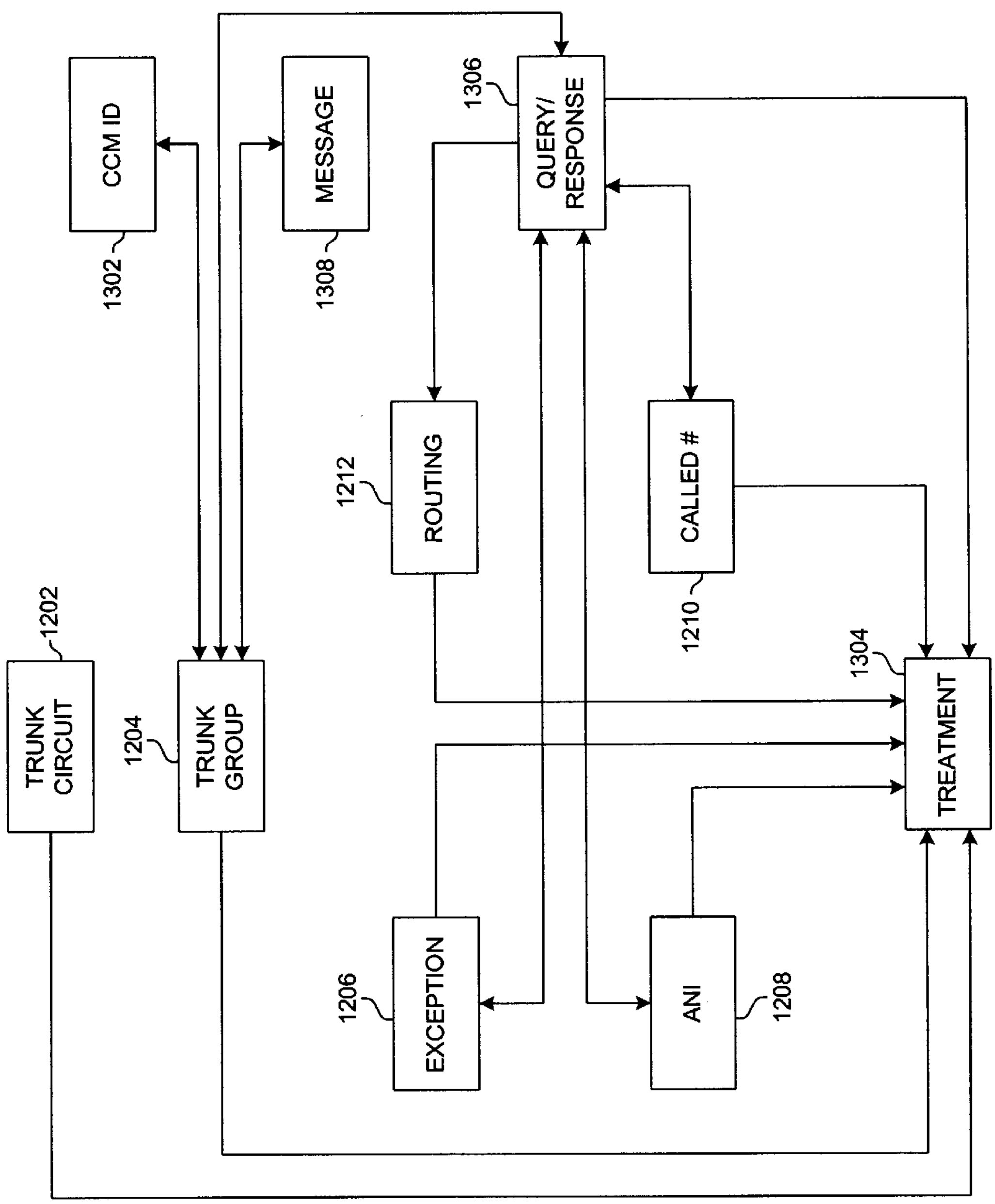
CCM ID
1302
MESSAGE
1308
1306
QUERY/ RESPONSE
1212
ROUTING
CALLED #
1210
1202
TRUNK CIRCUIT
1204
TRUNK GROUP
1304
TREATMENT
1206
EXCEPTION
ANI
1208

FIG. 13

ASSOCIATED POINT CODE	CIC	VP	VC	TRUNK GROUP NUMBER	GROUP MEMBER NUMBER	HARDWARE IDENTIFIER	ECHO CANCELER	ECHO CONTROL	SATELLITE INDICATOR	CIRCUIT STATUS	CIRCUIT STATE	TIME/DATE

FIG. 14

TRUNK GROUP NUMBER	GLARE RESOLUTION	CONTINUITY CONTROL	CLLI	SATELLITE TRUNK GROUP	SERVICE INDICATOR	ASSOCIATED NPA	SELECTION SEQUENCE	HOP COUNTER	ACC ACTIVE	OMI	NEXT FUNCTION	INDEX

FIG. 15

EXCEPTION TABLE INDEX	CARRIER SELECTION IDENTIFICATION	CARRIER IDENTIFICATION	CALLED PARTY			NEXT FUNCTION	INDEX
			NATURE OF ADDRESS	DIGITS FROM	DIGITS TO		

FIG. 16

ANI TABLE INDEX	CALLING PARTY CATEGORY	NATURE OF ADDRESS	CALLING PARTY/CHARGE NUMBER			ORIGINATING LINE INFORMATION	NEXT FUNCTION	NEXT INDEX
			DIGITS FROM	DIGITS TO	DATA			

FIG. 17

CALLED NUMBER TABLE INDEX	NATURE OF ADDRESS	DIGITS FROM	DIGITS TO	NEXT FUNCTION	NEXT INDEX

FIG. 18

ROUTING TABLE INDEX	TRANSIT NETWORK SELECTION			CIRCUIT CODE	NEXT FUNCTION #1	INDEX #1	NEXT FUNCTION #2	INDEX #2	NEXT FUNCTION #3	INDEX #3
	NETWORK IDENTIFICATION PLAN	DIGITS FROM	DIGITS TO							

FIG. 19.

INDEX	MESSAGE RECEIVED CAUSE VALUE	GENERAL LOCATION	CODING STANDARD	CAUSE VALUE	NEXT FUNCTION	INDEX

FIG. 20

MESSAGE TYPE	PARAMETERS	INDEX #1	INDEX #....	INDEX #N
ADDRESS COMPLETE	BACKWARD CALL INDICATOR			
	ACCESS TRANSPORT			
	CAUSE INDICATOR			
	OPTIONAL BACKWARD CALL INDICATORS			
	OPTIONAL "FE" INDICATOR			
ANSWER	ACCESS TRANSPORT			
	BACKWARD CALL INDICATOR			
CALL PROGRESS	EVENT INFORMATION			
	BACKWARD CALL INDICATOR			
	ACCESS TRANSPORT			
	CAUSE INDICATOR			
	OPTIONAL BACKWARD CALL INDICATOR			
CIRCUIT RESERVATION	NATURE OF CONNECTION INDICATOR			
CIRCUIT RESERVATION ACK	N/A			
CONFUSION	N/A			
CONTINUITY	CONTINUITY INDICATOR			
EXIT	OUTGOING TRUNK GROUP NUMBER			
INFORMATION	ALL PARAMETERS			
INFORMATION REQUEST	ALL PARAMETERS			
INITIAL ADDRESS	NATURE OF CONNECTION INDICATOR			
	FORWARD CALL INDICATOR			
	CALLING PARTY'S CATEGORY			
	USER SERVICE INFORMATION			
	CALLED PARTY NUMBER			
	ACCESS TRANSPORT			
	CALLING PARTY NUMBER			
	CARRIER IDENTIFICATION			
	CARRIER SELECTION INFORMATION			
	CHARGE NUMBER			
	GENERIC ADDRESS			
	ORIGINATING LINE INFORMATION			
	ORIGINAL CALLED NUMBER			
	REDIRECTING NUMBER			
	SERVICE CODE			
	TRANSIT NETWORK SELECTION			
	HOP COUNTER			
PASS ALONG	ALL PARAMETERS			
RELEASE	CAUSE INDICATOR			
	ACCESS TRANSPORT			
	AUTOMATIC CONGESTION CONTROL			
RELEASE COMPLETE	N/A			
RESUME	SUSPEND/RESUME INDICATOR			
SUSPEND	SUSPEND/RESUME INDICATOR			

FIG. 21

SYSTEM AND METHOD FOR PROVIDING ENHANCED SERVICES FOR A TELECOMMUNICATION CALL

RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 09/272,932, now U.S. Pat. No. 6,535,483 entitled "SYSTEM AND METHOD FOR PROVIDING ENHANCED SERVICES FOR A TELECOMMUNICATION CALL", filed on Mar. 18, 1999, and which is a continuation of Ser. No. 08/754,847 U.S. Pat. No. 5,920,562, entitled "SYSTEM AND METHOD FOR PROVIDING ENHANCED SERVICES FOR A TELECOMMUNICATION CALL", filed on Nov. 22, 1996, and which is hereby incorporated by reference into this application.

FEDERALLY SPONSERED RESEARCH OR DEVELOPMENT

Not applicable

MICROFICHE APPENDIX

Not applicable

FIELD OF THE INVENTION

The present invention relates to the field of telecommunications transmission and processing.

SUMMARY OF THE INVENTION

The present invention comprises a system for providing services for a call from a first communication device in an asynchronous transfer mode format. The call has user communications and call signaling. The system comprises a service platform adapted to receive the user communications. The service platform applies an interactive application to the user communications to process the user communications. The system further comprises a signaling processor adapted to receive the call signaling from the first communication device and to process the call signaling to select a first connection to the service platform. The signaling processor transports a processor control message designating the selected first connection. The system also comprises an interworking unit adapted to receive the processor control message from the signaling processor and to receive the user communications from the first communication device. The interworking unit converts the user communications from the asynchronous transfer mode format to a format usable by the service platform and uses the processor control message to transport the converted user communications to the service platform.

Further, the present invention is a system for providing services for a call from a first communication device in a time division multiplex format. The call has user communications and call signaling. The system comprises a service platform adapted to receive the user communications in an asynchronous transfer mode format. The service platform applies an interactive application to the user communications to process the user communications. The system further comprises a signaling processor adapted to receive the call signaling from the first communication device and to process the call signaling to select a first connection to the service platform. The signaling processor transports a processor control message designating the selected first connection. The system further comprises an interworking unit adapted to receive the processor control message from the signaling processor and to receive the user communications from the first communication device. The interworking unit interworks the user communications from the time division multiplex format to asynchronous transfer mode formatted cells that identify the selected first connection to the service platform.

In another aspect, the present invention is a method for connecting a call from a first communication device through an asynchronous transfer mode system. The call has user communications and call signaling. The method comprises receiving the call signaling in a signaling processor. The call signaling is processed to select a selected first one of a plurality of connections to a service platform for the user communications. A processor control message is transported from the signaling processor designating the selected first connection. The method further comprises receiving the user communications and the processor control message in an interworking unit. The user communications are converted in the interworking unit from the asynchronous transfer mode format to a format that is compatible with the service platform in response to the processor control message and transported from the interworking unit over the selected first connection to the service platform. The user communications are received in the service platform and processing the user communications.

In yet another aspect, the present invention is a method for connecting a call from a first communication device in a time division multiplex format. The call has user communications and call signaling. The method comprises receiving the call signaling in a signaling processor and processing the call signaling to select a selected first one of a plurality of connections to a service platform for the user communications. The processor control message is transported from the signaling processor designating the selected first connection. The user communications and the processor control message are received in an interworking unit. The method further comprises converting the user communications in the interworking unit from the time division multiplex format to asynchronous transfer mode formatted cells that identify the selected first connection to the service platform and transporting the converted user communications from the interworking unit over the selected first connection to the service platform. The user communications are received in the service platform and processing the user communications.

In still another aspect, the present invention is a system for connecting a call in an asynchronous transfer mode system. The call has user communications and call signaling. The system comprises a first communication device adapted to transport the call, a service node adapted to process the user communications, and a signaling processor adapted to receive the call signaling and to process the call signaling to select a connection to the service node. The signaling processor transports a processor control message designating the selected connection. The system also comprises an interworking unit located in the asynchronous transfer mode system adapted to receive the user communications from the first communication device, to receive the processor control message from the signaling processor, and to use the processor control message to route the user communications to the service node over the selected connection.

Still further, the present invention is a method for connecting a call through an asynchronous transfer mode system to a service node. The call has user communications and call signaling. The method comprises transporting the call from a communication device, the user communications comprising asynchronous transfer mode cells. The method includes receiving the call signaling in a signaling processor

and processing the call signaling to select one of a plurality of connections to the service node. A processor control message is transported from the signaling processor designating the selected connection. The user communications and the processor control message are received in an interworking unit. The method further comprises converting the user communications from the asynchronous transfer mode cells to a format usable by the service node and using the processor control message to route the user communications to the service node over the selected connection and processing the user communications in the service node.

The present invention further comprises a method for connecting a call having user communications through an asynchronous transfer mode system. The method comprises selecting in a processor a selected one of a plurality of connections to a service platform for the user communications. An interworking unit is notified which one of the plurality of connections was selected. The user communications are received in the interworking unit. The user communications are converted in the interworking unit from the asynchronous transfer mode format to a format that is compatible with the service platform. The converted user communications are transported in real time from the interworking unit over the selected connection to the service platform.

DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of a service platform system in accordance with the present invention.

FIG. **2** is a block diagram of a service platform system operating with a time division multiplex device in accordance with the present invention.

FIG. **3** is a block diagram of a service platform system with an extended asynchronous transfer mode system in accordance with the present invention.

FIG. **4** is a message sequence chart for a service platform in accordance with the present invention.

FIG. **5** is a message sequence chart for a plurality of service platforms.

FIG. **6** is a message sequence chart for a service platform with a plurality of media processors in accordance with the present invention.

FIG. **7** is a functional diagram of a plurality of service platforms interacting in an asynchronous transfer mode system.

FIG. **8** is a block diagram of a plurality of service platforms interacting in an asynchronous transfer mode system.

FIG. **9** is a functional diagram of an asynchronous transfer mode interworking multiplexer for use with a synchronous optical network system in accordance with the present invention.

FIG. **10** is a functional diagram of an asynchronous transfer mode interworking multiplexer for use with a synchronous digital hierarchy system in accordance with the present invention.

FIG. **11** is a block diagram of a signaling processor constructed in accordance with the present system.

FIG. **12** is a block diagram of a data structure having tables that are used in the signaling processor of FIG. **11**.

FIG. **13** is a block diagram of additional tables that are used in the signaling processor of FIG. **12**.

FIG. **14** is a table diagram of a trunk circuit table used in the signaling processor of FIG. **13**.

FIG. **15** is a table diagram of a trunk group table used in the signaling processor of FIG. **13**.

FIG. **16** is a table diagram of an exception circuit table used in the signaling processor of FIG. **13**.

FIG. **17** is a table diagram of an automated number index table used in the signaling processor of FIG. **13**.

FIG. **18** is a table diagram of a called number table used in the signaling processor of FIG. **13**.

FIG. **19** is a table diagram of a routing table used in the signaling processor of FIG. **13**.

FIG. **20** is a table diagram of a treatment table used in the signaling processor of FIG. **13**.

FIG. **21** is a table diagram of a message table used in the signaling processor of FIG. **13**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A call is a request for telecommunication services. Telecommunication systems provide services and processing for telecommunication calls between communication devices. Each call has call signaling and user communications. The user communications contain the caller's information, such as a voice communication or data communication, and they are communicated over a connection. Call signaling contains information that facilitates call processing, and it is communicated over a link. Call signaling, for example, contains information describing the called number and the calling number. Examples of call signaling are standardized signaling, such as SS7, C7, integrated services data network (ISDN), and digital private network signaling system (DPNSS).

A call can be transmitted from a communication device. A communication device can be, for example, customer premises equipment, a call processing platform, a switch, or any other device capable of initiating, handling, or terminating a call. Customer premises equipment can be, for example, a telephone, a computer, a facsimile machine, or a private branch exchange. A call processing platform can be, for example, a service platform or any other enhanced platform that is capable of processing calls.

The user communications and the call signaling may be transported by a communication device through an in-band transmission, such as superframe (SF) or extended superframe (ESF), over a time division multiplex (TDM) carrier such as a digital signal (DS) level communication line. Digital signal level zero (DS0), digital signal level one (DS1), and digital signal level three (DS3) are common designations that carry in-band communications. Other equivalent designations also carry in-band traffic. For example, European communication systems such as European level one (E1), European level 2 (E2), European level 3 (E3), and European level four (E4) are common designations that carry in-band communications.

In addition, call signaling and user communications may be transported out-of-band on separate transport paths, separate transport channels, separate transport connections, or separate transport media. These transports may be carried over DS level or equivalent European level media, as well as higher speed optical and electrical systems, such as synchronous optical network (SONET) and synchronous digital hierarchy (SDH). For example, signaling system 7 (SS7) and the European equivalent, C7, transport signaling traffic out-of-band. Moreover, narrowband systems such as ISDN and broadband systems such as broadband integrated services data network (B-ISDN), including B-ISDN over

asynchronous transfer mode (ATM), transport call signaling and user communications out-of-band.

Broadband systems provide greater bandwidth than narrowband systems for calls, in addition to providing digital processing of the calls, error checking, and correction. ATM is one technology that is being used in conjunction with SONET and SDH to provide broadband call switching and call transport for telecommunication services.

ATM is a protocol that describes communication of user communications in ATM cells. Because the protocol uses cells, calls can be transported on demand for connection-oriented traffic, connectionless-oriented traffic, constant-bit traffic, variable-bit traffic including bursty traffic, and between equipment that either requires timing or does not require timing.

ATM systems handle calls over switched virtual paths (SVPs) and switched virtual circuits (SVCs). The virtual nature of ATM allows multiple communication devices to use a physical communication line at different times. This type of virtual connection more efficiently uses bandwidth, and thereby provides more cost efficient transport for customer calls, than permanent virtual circuits (PVCs) or other dedicated circuits.

The ATM system is able to connect a caller from an origination point to a destination point by selecting a connection from the origination point to the destination point. The connection contains a virtual path (VP) and a virtual channel (VC). A VC is a logical connection between two end points for the transfer of ATM cells. A VP is a logical combination of VCs. The ATM system designates the selected connection by specifying a virtual path identifier (VPI) that identifies the selected VP and a virtual channel identifier (VCI) that identifies the selected VC within the selected VP. Because ATM connections are uni-directional, bi-directional communications in an ATM system usually require companion VPIs/VCIs.

The SONET and SDH protocols describe the physical media and protocols upon which the communication of ATM cells takes place. SONET includes optical transmission of optical carrier (OC) signals and electrical transmission of synchronous transport signals (STSs). SONET signals transmit at a base rate of 51.84 Mega-bits per second (Mbps) for optical carrier level one (OC-1) and synchronous transport signal level one (STS-1). Also transmitted are multiples thereof, such as an STS level three (STS-3) and an OC level three (OC-3) at rates of 155.52 Mbps and an STS level twelve (STS-12) and an OC level 12 (OC-12) at rates of 622.08 Mbps, and fractions thereof, such as a virtual tributary group (VTG) at a rate of 6.912 Mbps. SDH includes transmission of optical synchronous transport module (STM O) signals and electrical synchronous transport module (STM E) signals. SDH signals transmit at a base rate of 155.52 Mbps for synchronous transport module level one electrical and optical (STM-1 E/O). Also transmitted are multiples thereof, such as an STM level four electrical/optical (STM-4 E/O) at rates of 622.08 Mbps, and fractions thereof, such as a tributary unit group (TUG) at a rate of 6.912 Mbps.

Telecommunication systems require call setup information to initiate a connection between communication devices. The call setup uses information in the call signaling to make the correct connection between the communication devices so that the user communications can be transported across the connection between the communication devices.

Calls are placed to a service provider. The service provider processes the call signaling and, based on the information in the call signaling, provides a selected service to process the call. Many calls require only general processing and general services such as basic call routing to the destination point from the originating point or other basic services.

However, enhanced services are sometimes required for call processing. Such enhanced services are generally located at a service node in a service platform and can process the user communications in response to control messages. These enhanced services often use digital signal processing, application programs, and database storage to perform the required processing for the enhanced services. These enhanced services often provide interactive calling features that require a caller to interact with telecommunication network equipment in order to achieve an enhanced service. For example, a call might require voice recognition processing prior to allowing the caller access to an information database. Such a call would likely require enhanced services in which the caller interacts with a voice recognition processor in the telecommunication network.

A system and method are required to dynamically transfer calls through an ATM system to a service platform. The ATM system contains telecommunication communication devices, such as a communication device, a call destination device, and switching equipment, that allows the call to be transported to the correct destination in the ATM network. Thus, there is a need for a system and method to connect calls passing through an ATM system to devices, such as service platforms, that can provide enhanced services. Moreover, this should be completed on a call-by-call basis in real time.

The Service Platform Systems

The system of the present invention provides call transmission and call switching in real time in an ATM system within a telecommunication network. The system connects calls passing through the ATM system to service nodes having service platforms that can provide enhanced services for processing the calls. Moreover, it is possible to select specific interactive applications within a service platform to process each call.

FIG. **1** illustrates the use of a service platform system in accordance with the present invention. A telecommunication system **102** has a service platform system **104** that interacts with a first communication device **106** and a second communication device **108**. The service platform system **104** contains a signaling processor **110**, a service platform **112**, and an interworking unit **114**. The service platform system **104** can receive one or more calls and route the calls to the appropriate device. The service platform system **104** processes calls using interactive applications.

Links are used to transport call signaling and control messages. The term "link" as used herein means a transmission media used to carry call signaling and control messages. For example, a link carries call signaling or a device control message containing device instructions and/or data. A link can carry, for example, out-of-band signaling such as SS7, C7, ISDN, B-ISDN, GR-303, local area network (LAN), or data bus call signaling. A link can be, for example, an AAL5 data link, UDP/IP, eithemet, or a DS0 over T1. In addition, a link, as shown in the figures, can represent a single physical link or multiple links, such as one link or a combination of links of ISDN, SS7, TCP/IP, or some other data link. The term "control message" as used herein means a control or signaling message, a control or signaling instruction, a control or signaling signal, or signaling instructions, whether proprietary or standardized, that convey information from one point to another.

Connections are used to transport user communications and other device information between the elements and devices of the telecommunication system **102**. The term "connection" as used herein means the transmission media used to carry user communications between communication devices or between the elements of the telecommunication system **102**. For example, a connection can carry a user's voice, computer data, or other communication device data. A connection can be associated with either in-band communications or out-of-band communications.

A system of links and connections connect the elements of the telecommunication system **102**. The signaling processor **110** communicates to the first communication device **106** through a link **116**, to the service platform **112** through a link **118**, to the interworking unit **114** through a link **120**, and to the second communication device **108** through a link **122**. The interworking unit **114** communicates to the first communication device **106** through a connection **124**, to the service platform **112** through a connection **126**, and to the second communication device **108** through a connection **128**. It shall be appreciated that other links can extend from the signaling processor **110** to other systems, networks, or devices. In addition, other connections may extend from the interworking unit **114** or from the first and second communication devices **106** and **108** to other systems, networks, or devices.

Each of the first and second communication devices **106** and **108** comprises customer premises equipment, a call processing platform, a switch, or any other device capable of initiating, handling, or terminating a call, including a telephone, a computer, a facsimile machine, a private branch exchange, a service platform, or an enhanced platform that is capable of processing calls. It will be appreciated that other communication devices may be included. However, the number of communication devices shown has been restricted for clarity.

The signaling processor **110** of the service platform system **104** accepts call signaling or control messages from, and transmits call signaling or control messages to, all other elements and devices. The signaling processor **110** thereby controls call routing and call processing in the telecommunication system **102**. One embodiment of the signaling processor **110** is discussed in more detail below.

The service platform **112** provides enhanced services for the user communications received by the interworking unit **114**. The service platform **112** may have one or multiple applications to provide multiple services. Such services may include voice messaging, facsimile messaging, mail boxes, voice recognition, conference bridging, calling card, menu routing, N00 servicing such as freephone and 900 call servicing, prepay card, tone detection, and call forwarding.

The service platform **112** receives control messages from the signaling processor **110**. The control messages instruct the service platform **112** which application to use in the service platform to process the user communications. The service platform **112** processes the user communications and returns processing data results to the signaling processor **110**. In addition, the service platform **112** returns the processed user communications to the interworking unit **114** to be transported back to the first or second communication device **106** or **108**.

The interworking unit **114** interworks connections on a call-by-call basis. The interworking unit **114** may be an ATM interworking multiplexer that interworks between the ATM format and other formats while providing multiplexing and demultiplexing functions, or it may be an ATM interworking unit that interworks between different types of ATM systems and provides domain addressing. In addition, the interworking unit **114** may be a unit with domain addressing capabilities only, an ATM multiplexer that provides multiplexing and demultiplexing functions for ATM cells, or other types of interworking units.

The interworking unit **114** accepts user communications from, and transports user communications to, the first communication device **106**, the second communication device **108**, and the service platform **112**. Preferably, the interworking unit **114** is an ATM interworking multiplexer that interworks between the first communication device **106** that communicates user communications in a TDM format over a DS0, the service platform **112** that communicates user communications in the TDM format over a DS0, and the second communication device **108** that communicates user communications in the ATM format over a SONET pipe or an SDH pipe. However, it will be appreciated that the first and second communication devices **106** and **108** may be either TDM or ATM devices, and interworking can be completed between any formats. One type of interworking unit that is compatible with the present system is discussed more fully below.

The interworking unit **114** accepts control messages from, and sends control messages to, the signaling processor **110**. The interworking unit **114** uses the information gained from the signaling processor's control message to identify the required interworking assignment so that the user communications are converted between the formats that are compatible with the first communication device **106**, the second communication device **108**, and the service platform **112**.

A selected connection is designated by a selected VPI/VCI for ATM formatted transmissions, or a selected DS0 for TDM transmissions. The interworking unit **114** therefore dynamically interworks selected VPI/VCIs to selected DS0s and dynamically interworks selected DS0s to selected VPI/VCIs. Because DS0 communications are bi-directional and ATM communications are typically uni-directional, companion VPI/VCIs may be required for interworking between a DS0 and ATM.

In addition, the interworking unit **114** has a TDM interworking function which allows the interworking unit to transport the user communications between the service platform **112** and the first or second communication devices **106** or **108** without converting the user communications to another format. This can occur, for example, when the user communications that are transferred from the first or second communication device **106** or **108** are in the same format as the format usable by the service platform **112**.

Referring back to FIG. **1**, the system operates as follows. In the preferred enhanced service processing system, a call is received into the service platform **112** from a communication device, such as the second communication device **108**. The call signaling is transported from the second communication device **108** to the signaling processor **110**. The user communications are transported in ATM cells from the second communication device **108** to the interworking unit **114**.

The signaling processor **110** processes the call signaling. The signaling processor **112** reads the call characteristics such as the routing label, including the origination point code (OPC), the destination point code (DPC), the circuit identification code (CIC), or the signaling link selection (SLS). Based on the processing of the call characteristics in the call signaling, the signaling processor **110** determines what action is to be taken, which service the call requires, and, when a plurality of service platforms exist, which service platform and which application in the service plat-

form can provide the service. The signaling processor **110** sends a processor control message to the selected service platform **112** designating the application that is to process the user communications.

In addition, based on the call signaling processing, the signaling processor **110** selects a connection **126** from the interworking unit **114** to the service platform **112** for the user communications. The signaling processor **110** sends a processor control message to the interworking unit **114** designating the selected connection.

The interworking unit **114** receives both the user communications from the second communication device **108** and the processor control message from the signaling processor **110**. The interworking unit **114** converts the ATM cells containing the user communications to a form that is compatible with the service platform **112**. Generally, the ATM cells are converted into a TDM format. The interworking unit **114** then uses the information gained from the processor control message to route the user communications to the service platform **112** over the selected connection **126**. The selected connection **126** is generally a selected DS0.

The service platform **112** receives both the user communications from the interworking unit **114** and the processor control message from the signaling processor **110**. The service platform **112** uses the information in the processor control message to process the user communications using the selected interactive application. When the application has completed, the service platform **112** transmits the processing results to the signaling processor **110** and the processed user communications to the interworking unit **114** to be transported either back to the second communication device **108** or to another service platform or device (not shown). The processing results contain control messages and data that allows the signaling processor **110** to reroute the processed user communications to another service platform, to the second communication device **108**, or to the first communication device **106**.

If the user communications are transported to the second communication device, the user communications must be interworked to ATM cells that identify the VPI/VCI of the selected connection **128**. If, however, the user communications are transported to the first communication device **106**, the user communications do not need to be converted to ATM cells. In the present example, the user communications are transported to the first communication device **106**. The processing results and processed user communications are transported to the signaling processor **110** and the first communication device **106**, respectively, either throughout the duration of the call or at the completion of the call.

In addition to transferring the processing results, the service platform **112** also transmits a service complete signal to the signaling processor **110**. The signaling processor **110** receives the service complete signal and the processing results and processes them to determine if the processed user communications are to be transferred to a different device.

If more processing is required, the signaling processor **110** selects a connection and transmits a processor control message to the interworking unit **114** designating the new selected connection to either the second communication device **108** or to a new selected device (not shown). If the selected device is an ATM device, the interworking unit **114** converts the processed user communications which it received from the service platform **112** to ATM cells that identify the selected connection. The ATM cells would, for example, identify the VPI/VCI of the connection to the selected device. The interworking unit **114** then transmits the ATM cells over the connection to the selected device. The conversion of the user communications to ATM cells and the transmission of the ATM cells over the connection occurs dynamically in real time.

It will be appreciated that the call can be handled, initiated, or terminated by either of the first or second communication devices **106** or **108**. For example, the user communications can be transported by the first communication device **106** and received ultimately by the second communication device **108**. Alternately, the user communications can be transported from one of the first or second communication devices **106** or **108**, processed by the service processor **112**, and transported back to the same communication device **106** or **108**.

Also, it will be appreciated that, although in the above-described operation of the system the first communication device **106** was a TDM device, the service platform **112** was a TDM device, and the second communication device **108** was an ATM device, the first and second communication devices **106** and **108** and the service platform **112** can receive, transport, and handle user communications in any required format. Thus, the user communications can be processed in a system where the first communication device **106** is an ATM device, the service platform **112** is a TDM device, and the second communication device **108** is a TDM device or in a system where the first communication device **106** is an ATM device, the service platform **112** is a TDM device, and the second communication device **108** is an ATM device. In addition, the user communications can be processed in a system where the first communication device **106** is an ATM device, the service platform **112** is an ATM device, and the second communication device **108** is an ATM device or in a system where the first communication device **106** is a TDM device, the service platform **112** is an ATM device, and the second communication device **108** is a ATM device. In each of these instances, the signaling processor **110**, the service platform **112**, and the interworking unit **114** operate similarly to the operation described above. As one skilled in the art will appreciate, the interworking for the user communications will be determined according to the format of the devices.

FIG. **2** illustrates a telecommunication system **102** in which an ATM cross connect **230** is used to route calls. The cross connect **230** has a connection **232** to the second communication device **108** and a connection to the interworking unit **114**. The cross connect **230** receives ATM cells from the interworking unit **114** over the connection **234** and directs the ATM cells to the second communication device **108** over the connection **232** therebetween. Alternatively, the cross connect **230** can route calls to another ATM system over a connection **236**.

As illustrated in the telecommunication system **102** of FIG. **3**, a service platform system **104**A may contain many elements. A first communication device **106** and a second communication device **108** interact with the service platform system **104**A. The service platform system **104**A contains a signaling processor **110** and a service platform **112**A.

In addition, the service platform system **104**A contains a service control point **336**, a service database **338**, and an interworking multiplexer (mux) **340**. The service platform **112**A contains a host computer **342**, a first media processor **344**, and a second media processor **346**. However, a service platform can have greater or fewer media processors in addition to other devices.

Call signaling and control messages are carried between the telecommunication system **102** devices on links. The signaling processor **110** communicates to the first communication device **106** through a link **116**, to the second

communication device **108** through a link **122**, to the service control point **336** through a link **348**, to the service database **338** through a link **350**, to the interworking mux **340** through a link **352**, and to the host computer **342** through a link **354**. Preferably, the links **116**, **122**, **348**, **350**, **352**, and **354** are a LAN, SS7 links, or SS7 over ATM.

The host computer **342** communicates with the first media processor through a link **356**, to the second media processor **346** through a link **358**, and to the service database **338** through a link **360**. Preferably, links **356**, **358**, and **360** are either a LAN or a data bus.

User communications are carried between the telecommunication system **102** devices on connections. The interworking mux **340** communicates to the first communication device **106** through a connection **362**, to the second communication device **108** through a connection **364**, to the first media processor **344** through a connection **366**, and to the second media processor **346** through a connection **368**.

The service platform system **104**A can receive one or more calls and route the calls to the appropriate equipment. The signaling processor **110** accepts control messages from, and transmits control messages to, other elements and equipment. The signaling processor **110** thereby controls call routing and call processing in the telecommunication system

The service control point (SCP) **336** contains information about the telecommunication system **102** and how to route calls through the telecommunication network. The SCP **336** is queried by the signaling processor **110** to determine how to route calls with advanced routing features such as N00 or menu routing. The signaling processor **110** may pass the information it gains from the SCP **336** to the host computer **342** in the processor control message.

The service database **338** is a logically centralized data storage device from which the signaling processor **110** or the host computer **342** can retrieve communication device data or other device data. The service database **338** has two aspects of a user or device profile. First, the service database **338** has service subscription data and processing options which denote the services to which a particular call or communication device has access. Second, the service database **338** has service data which is stored on behalf of a call or communication device. Service data includes such information as voice messages, facsimile messages, and electronic mail.

The interworking mux **340** interworks between ATM cells and other call formats while providing multiplexing and demultiplexing functions. The interworking mux **340** accepts user communications from the second communication device **108** and from the first communication device **106**. The interworking mux **340** accepts a processor control message containing signaling and control information from the signaling processor **110**.

The processor control message from the signaling processor **110** designates a selected connection from the interworking mux **340** to either the first media processor **344** or the second media processor **346**. In addition, a processor control message designates a selected connection from the interworking mux **340** to either the first communication device **106** or the second communication device **108**. A selected connection is designated by a selected VPI/VCI or a selected DS0. The interworking mux **340** routes the user communications over the selected connection.

User communications are communicated back and forth between the interworking mux **340** to be transported to another device and either the first media processor **344** or the second media processor **346**, or both. The interworking mux **340** uses the information gained from the signaling processor's processor control message to convert the user communications received from the second communication device **108**, for example, between ATM cells and a format that is compatible with the media processors **344** and **346**.

The media processors **344** and **346** contain applications that process the user communications. The media processors **344** and **346** perform such processing as tone detection and collection. The media processors **344** and **346** collect any information from the user communications that is required to complete an application or manipulate the user communications. The media processors **344** and **346** run applications that process voice and tones. The media processors **344** and **346** report the processing results of the processed data to the host computer **342** or to the signaling processor **110** in a media data signal. In some instances, raw data from the user communications and processed user communications are transferred to the host computer **342** for further processing.

In one embodiment, the system operates as follows where a call is initiated from the second communication device **108** and the processed user communications return to the second communication device. The host computer **342** is the service node manager that controls devices on the service node or service platform **112**A. The host computer **342** receives a processor control message from the signaling processor **110**. The processor control message instructs the host computer **342** which application to use in the media processors **344** and **346** to process the user communications. The host computer **342** controls the user communications processing in the media processors **344** and **346** and returns processed data results to the signaling processor **110** in a host computer data signal. The host computer **342** instructs the media processors **344** and **346** to return the processed user communications to the interworking mux **340** to be transported back to the second communication device **108**. The host computer **342** may also send a host control message to the signaling processor **110** with control messages such as a service complete message. It will be appreciated that other calls can be placed to and from other devices.

In another embodiment, the system operates as follows where the first communication device **106** places a call that is to be processed and returned to the first communication device. The call signaling is transported to the signaling processor **110** so that the signaling processor **110** can route the call to the appropriate device. The user communications are transported to the interworking mux **340** to be transported to an appropriate service, such as the media processors **344** and **346**. After the user communications are processed, it is transported from the media processors **344** or **346**, through the interworking mux **340**, and back to the first communication device **106**. The first communication device **106** can transmit the call in a variety of formats, including SF, ESF, ISDN, B-ISDN, and GR-303 and over a variety of transmission media including TDM, SONET, and SDH.

Referring still to FIG. **3**, the operation of the system **104**A is as follows. In the system, the signaling processor **110** controls the host computer **342** and the media processors **344** and **346** that process user communications which pass through an ATM system. The signaling processor **110** selects connections as needed to connect the devices in the telecommunication system **102**.

A call is received into the service platform system **104**A from the second communication device **108**. The call signaling is transported from the second communication device **108** to the signaling processor **110**. The user communications are transported in ATM cells from the second communication device **108** to the interworking mux **340**.

The signaling processor **110** processes the call signaling. The signaling processor **110** processes the call characteristics in the call signaling. Based on the processing of the call characteristics, the signaling processor **110** determines which service the call requires and which host computer and media processor and which application in the media processor can provide the service.

However, sometimes the call characteristics are not sufficient to determine the specific communication device that is requesting a service or to determine the specific requested service desired. This may occur, for example, when a device dials an "800" number to gain access to a calling card service. In such a situation, a service application may require a personal identification code before access to a service is provided. The signaling processor **110** then may invoke applications in the signaling processor **110** or in the media processor **344** that can interact with the call to determine the device identity or desired service.

In addition, the signaling processor **110** may query the SCP **336** or the service database **338**. This would allow the signaling processor **110** to gain service options, service data, and routing information for the call to determine the required combination of signal processing, database, and connection providing elements to provide a service.

The call signaling is processed and the signaling processor **110** determines the resource needed to process the service request. The signaling processor **110** then sends a processor control message to the selected host computer **342** designating the application that is to process the user communications. In addition, based on the processed call signaling, the signaling processor **110** selects a connection from the interworking mux **340** to the media processor **344** selected to process the user communications. The signaling processor **110** sends a processor control message to the interworking mux **340** designating the selected connection **366** and instructing the interworking mux **340** to dynamically connect the call in real time to a service platform **112A** on the connection **366** and to convert the user communications in the interworking mux **340** from the ATM cells to a format that is compatible with the selected media processor **344**.

The interworking mux **340** receives both the user communications from the second communication device **108** and the processor control message from the signaling processor **110**. The interworking mux **340** converts the ATM cells containing the user communications to a form that is compatible with the selected media processor **344**. Generally, the ATM cells are converted into a TDM format. The interworking mux **340** then uses the information gained from the processor control message to route the user communications to the selected media processor **344** over the selected connection **366**.

The user communications are received in the selected media processor **344**. In addition, the host computer **342** transmits a host control message to the media processor **344** instructing the media processor **344** which application to use and providing other control messaging to control the processing of the user communications. The media processor **344** processes the user communications in accordance with the control messages from the host computer **342**. The media processor **344** then reports the processing results to the host computer **342** in a media processor signal over the link **354**. In addition, the media processor **344** transmits the processed user communications to the interworking mux **340**.

The host computer **342** can further service the processing results. The host computer **342** transfers the processing results, with or without further servicing, to the signaling processor **110** in a host control message. The host control message may request that the host computer **342** and the associated media processor **344** be released because processing is complete or it can request another service or media processor. When the signaling processor **110** receives the host control message, it may direct the interworking mux **340** to transfer the processed user communications to the second communication device **108** or to the first communication device **106**. In addition, the signaling processor **110** may direct the interworking mux **340** to transfer the processed user communications to another service platform or another media processor on the same service platform **112A**. If the processing is complete, the interworking mux **340** will be instructed by the signaling processor **110** to release the connection to the media processor **344**, at which point the connection will be released.

FIG. **4** illustrates the message transmissions for the user communications processing and the control messages that take place between the various telecommunication network devices to process a call. The message sequences illustrate the method for connecting a call through an ATM system to a service platform.

With reference to FIG. **3** and FIG. **4**, a communication device **108** transmits a call, including call signaling and user communications. The call signaling is received in the signaling processor **110**, and the user communications are transported to an interworking mux **340** upon a connection that was seized by the second communication device **108**.

The signaling processor **110** processes the call signaling to determine which application and service platform is required to process the user communications. The signaling processor **110** selects a connection to the selected service platform **112A**. The signaling processor **110** transmits a processor control message to the service platform **112A** requesting service for the user communications. The service request designates the application that will process the user communications and designates the connection between the service platform **112A** and the interworking mux **340** upon which the user communications will be transported.

In addition, the signaling processor **110** transmits a processor control message to the interworking mux **340** designating the selected connection assignment to the selected service platform **112A**. When the service platform **112A** is connected to the interworking mux **340** by a DS level transmission line, the connection assignment is a TDM port number, such as a DS0 port designation or an E0 port designation.

The interworking mux **340** connects to the service platform **112A** on the selected connection. When the service platform **112A** is in a TDM system and the second communication device **108** is in an ATM system and is transmitting the user communications in ATM cells, the interworking mux **340** interworks the VPI/VCI of the connection from which the ATM cells are being received to the DS0 or E0 of the connection to the service platform **112A**. When, however, processed user communications are being transported from the service platform **112A** to the interworking mux **340**, the interworking mux interworks the DS0 or E0 of the connection from which the processed user communications are being received from the service platform **112A** to the VPI/VCI of the selected connection to the second communication device **108** or other selected communication device **108**. The VPI/VCI of the selected connection back to the second communication device **108** or to some other selected communication device is designated in a processor control message. The second communication device **108** and the service platform **112A** may interact, thereby transmitting

user communications to each other through the interworking mux **340** over the selected connection.

The interworking mux **340** interworks the user communications transmission between the format of the second communication device **108** and a format compatible with the service platform **112**A. In the preferred method, the user communications are converted from ATM cells received from the second communication device **108** to a TDM format that is transported over a DS0 or E0 to the service platform **112**A. In the reverse direction, processed user communications received from the service platform **112**A over the DS0 or E0 in the TDM format are converted to ATM cells that identify the VPI/VCI for the connection to the second communication device **108**, or to some other selected device. The selected connection designations for both the second communication device **108** and the service platform **112**A are received in the interworking mux **340** from the signaling processor **110**.

When the processing of the user communications is completed by the service platform **112**A, it transmits to the signaling processor **110** a control message having a service complete message. Upon receiving the control message, the signaling processor **110** sends a processor control message to the interworking mux **340** requesting that the connection be terminated and to the second communication device **108** requesting that the connection be released. In response to the processor control message, the connections are disconnected.

With reference to FIG. **3** and FIG. **5**, after a connection has been made and the user communications have been processed in a first media processor, the signaling processor **110** may determine that further processing is required and select an application in the second media processor **346** to further process the user communications. The signaling processor **110** would transmit a second processor control message to the interworking mux **340** designating a second selected connection **368** to the second media processor **346**.

In response to the second processor control message, the interworking mux **340** disassociates the connection to the first media processor **344** and makes the second selected connection to the second media processor **346**. Then, the interworking mux **340** transmits the user communications to the second media processor **346** over the second selected connection.

In addition, the signaling processor transmits another processor control message to the host computer **342** designating a selected application in the second media processor **346** to process the user communications. In response to the processor control message, the host computer **342** transmits a host control message to the second media processor **346** to control processing of the user communications and reporting of the processing results.

FIG. **5** illustrates the message transmissions that take place between the various telecommunication system **102** devices to further process user communications in a second media processor **346**. The message sequences illustrate the method for connecting a call through an ATM system from a first media processor **344** to a second media processor **346** after a connection to the first media processor has been completed. Both media processors **344** and **346** are controlled by a single host computer **342**.

After the first connection is made by the interworking mux **340** and interaction occurs between the second communication device **108** and the first media processor **344** in the service platform **112**A (see FIG. **3**), the host computer **342** may request that further user communications processing be completed in the second media processor **346**. The

host computer **342** then transmits to the signaling processor **110** a host control message containing a service complete message. Alternatively, the signaling processor **110** may initiate the processing in the second media processor **346**.

Upon receiving the host control message, the signaling processor **110** selects a connection reassignment to the second media processor **346** and transmits to the interworking mux **340** a processor control message designating the second selected connection. In a TDM system, the designation of the second selected connection to the second media processor **346** is a TDM port designation, such as a DS0 or an E0.

Upon receiving the processor control message, the interworking mux **340** disassociates the connection to the first media processor **344** and interworks the user communications with the selected connection to the second media processor **346**. The second communication device **108** and the media processor device **346** interact as described above.

When the processing of the user communications are completed by the second media processor **346**, the host computer **342** transmits to the signaling processor **110** a host control message having a service complete message. Upon receiving the host control message, the signaling processor **110** sends a processor control message to the interworking mux **340** requesting that the connection be terminated and to the second communication device **108** requesting that the connection be released. In response to the processor control message, the connections are disconnected.

FIG. **6** illustrates the message transmissions that take place between the various telecommunication system devices to further process user communications in a second service platform **602** after the user communications first has been processed by a first service platform **112**A (see FIG. **3**). The message sequences illustrate the method for connecting a call through an ATM system from a first service platform **112**A to a second service platform **602** after a connection to the first service platform has been completed.

After the initial connection is made by the interworking mux **340** and interaction occurs between the second communication device **108** and the first service platform **112**A, the first service platform **112**A may require that further user communications processing be completed in the second service platform **602**. The first service platform would transmit to the signaling processor **110** a control message having a service complete. Alternatively, the signaling processor **110** may initiate the processing in the second service platform **602**.

Upon receiving the control message, the signaling processor **110** selects a connection reassignment to the second service platform **602** and transmits a processor control message to the interworking mux **340** designating the selected connection reassignment. In a TDM system, the designation of the selected connection to the second service platform **602** is a TDM connection designation, such as a DS0 or E0 designation.

Upon receiving the processor control message, the interworking mux **340** disassociates the connection to the first service platform **112**A and interworks the user communications to the selected connection to the second service platform **602**. The second communication device **108** and second service platform **602** can then interact as described above.

When the processing of the user communications are completed by the second service platform **602**, the second service platform transmits to the signaling processor **110** a control message having a service complete message. Upon receiving the control message, the signaling processor **110**

sends a processor control message to the interworking mux **340** requesting that the connection be terminated and to the second communication device **108** requesting that the connection be released. In response to the respective processor control messages, the connections are disconnected.

FIG. **7** illustrates the interaction that may take place between service platforms and communication devices when multiple service platforms are required for call processing or when call processing is required by a communication device that does not have local access to a service platform. For example, a local communication device **702** is connected to a local service platform system **704** which contains a local signaling processor **706**, a local service platform **708**, and a local ATM interworking mux **710**.

The local communication device **702** transmits a call to the local service platform system **704** for processing of the call by an inexpensive application or by an application that is used often. The call signaling is transported to the local signaling processor **706**, and the user communications are transported to the local ATM interworking mux **710**. The signaling processor **706** selects a connection to the local service platform **708** from the local ATM interworking mux **710** and transmits a processor control message to the local ATM interworking mux **710** designating the selected connection. In addition, the signaling processor transmits a processor control message to the local service platform **708** designating the application to process the user communications. The local ATM interworking mux **710** transmits the user communications to the local service platform **708** over the selected connection, and the local service platform **708** processes the user communications.

Alternatively, the local communication device **702** may transmit a call designated for a core service platform system **712**. The core service platform system **712** contains expensive applications or infrequently used applications that are shared by a plurality of communication devices and other devices in the telecommunication network. The core service platform system contains a core signaling processor **714**, a core service platform **716**, and a core ATM interworking mux **718**.

The local communication device **702** can access the core service platform system **712** by transporting call signaling to the local signaling processor **706**. The local signaling processor **706** transports the call signaling to the core signaling processor **714**.

In addition, the local communication device **702** transports user communications to the local ATM interworking mux **710**. The local ATM interworking mux **710** receives a processor control message from the local signaling processor designating a selected connection to the core ATM interworking mux **718** through an ATM cross connect system **720** and the VPI/VCI of the selected connection. The local ATM interworking mux **710** converts the user communications to ATM cells that identify the VPI/VCI of the selected connection and transmit the ATM cells to the ATM cross connect system **720**. The ATM cross connect system **720** cross connects the ATM cells to the selected connection with the VPI/VCI and routes the ATM cells to the core ATM interworking multiplexer **718**.

In addition, the core signaling processor **714** selects a connection to the core service platform **716** and transmits to the core ATM interworking mux **718** a processor control message designating the selected connection. The core ATM interworking mux **718** converts the ATM cells to user communications having a format that is compatible with the core service platform **716** and transmits the user communications over a selected connection to the core service platform **716** for processing. A processor control message from the core signaling processor **714** to the core service platform **716** designates the applications and controls to process the user communications.

In a similar fashion, a communication device **722** that does not have a local service platform can transmit a call to be processed by the core service platform system **712** or by the local service platform system **704**. The communication device **722** transmits call signaling to the communication device signaling processor **724** and user communications to the ATM interworking mux **726**. The signaling processor **724** controls transmission of the call signaling and the user communications to the appropriate system.

FIG. **8** illustrates the interaction of service platforms in a telecommunication network. In FIG. **8**, a local service platform system **802** interacts with an edge service platform system **804**. The edge platform system **804** likewise interacts with a core service platform system **806**. Any one of the service platform systems **802**, **804**, and **806** can transmit a call to any other system.

The ATM Interworking Multiplexer

FIG. **9** shows one embodiment of an ATM interworking multiplexer (mux) **902** that is suitable for the present invention, but other multiplexers that support the requirements of the invention are also applicable. The ATM interworking mux **902** has a control interface **904**, an OC-N/STS-N interface **906**, a DS3 interface **908**, a DS1 interface **910**, a DS0 interface **912**, a signal processor **914**, an ATM adaptation layer (AAL) **916**, an OC-M/STS-M interface **918**, and an ISDN/GR-303 interface **920**.

The control interface **902** accepts control messages from the signaling processor **922**. In particular, the control interface **904** identifies DS0 connections and virtual connection assignments in the control messages from the signaling processor **922**. These assignments are provided to the AAL **916** for implementation.

The OC-N/STS-N interface **906**, the DS3 interface **908**, the DS1 interface **910**, the DS0 interface **912**, and the ISDN/GR-303 interface **920** each can accept calls, including user communications, from a communication device **924**. Likewise, the OC-M/STS-M interface **918** can accept calls, including user communications, from a communication device **926**.

The OC-N/STS-N interface **906** accepts OC-N formatted communication signals and STS-N formatted communication signals and converts the communication signals from the OC-N or STS-N formats to the DS3 format. The DS3 interface **908** accepts communication signals in the DS3 format and converts the communication signals to the DS1 format. The DS3 interface **908** can accept DS3s from the OC-N/STS-N interface **906** or from an external connection. The DS1 interface **910** accepts the communication signals in the DS1 format and converts the communication signals to the DS0 format. The DS1 interface **910** can accept DS1s from the DS3 interface **908** or from an external connection. The DS0 interface **912** accepts communication signals in the DS0 format and provides an interface to the AAL **916**. The ISDN/GR-303 interface **920** accepts communication signals in either the ISDN format or the GR-303 format and converts the communication signals to the DS0 format. In addition, each interface may transmit signals in like manner to the communication device **924**.

The OC-M/STS-M interface **918** is operational to accept ATM cells from the AAL **916** and to transmit the ATM cells over the connection to the communication device **926**. The OC-M/STS-M interface **918** may also accept ATM cells in the OC or STS format and transmit them to the AAL **916**.

The AAL **916** comprises both a convergence sublayer and a segmentation and reassembly (SAR) sublayer. The AAL **916** is operational to accept call origination device information in the DS0 format from the DS0 interface **912** and to convert the call origination device information into ATM cells. AALs are known in the art and information about AALs is provided by International Telecommunications Union (ITU) document 1.363, which is hereby incorporated fully herein by reference. An AAL for voice communication signals is described in U.S. patent application Ser. No. 08/395,745, which was filed on Feb. 28, 1995, and entitled "Cell Processing for Voice Transmission," and which is incorporated herein by reference.

The AAL **916** obtains from the control interface **904** the virtual path identifier (VPI) and the virtual channel identifier (VCI) for each DS0 for each call connection. The AAL **916** also obtains the identity of the DS0 for each call (or the DS0s for an Nx64 call). The AAL **916** then transfers the call origination device information between the identified DS0 and the identified ATM virtual connection. An acknowledgment that the assignments have been implemented may be sent back to the signaling processor **922** if desired. Calls with multiple 64 Kilo-bits per second (Kbps) DS0s are known as Nx64 calls. If desired, the AAL **916** can be configured to accept control messages through the control interface **904** for Nx64 calls.

As discussed above, the ATM interworking mux **902** also handles calls in the opposite direction, that is, in the direction from the OC-M/STS-M interface **918** to the DS0 interface **912**, including calls exiting from the DS1 interface **910**, the DS3 interface **908**, the OC-N/STS-N interface **906**, and the ISDN/GR-303 interface **920**. For this traffic, the VPI/VCI has been selected already and the traffic has been routed through the cross-connect (not shown). As a result, the AAL **916** only needs to identify the pre-assigned DS0 for the selected VPI/VCI. This can be accomplished through a look-up table. In alternative embodiments, the signaling processor **922** can provide this DS0-VPI/VCI assignment through the control interface **904** to the AAL **916**.

A technique for processing VPI/VCIs is disclosed in U.S. patent application Ser. No. 08/653,852, which was filed on May 28, 1996, and entitled "Telecommunications System with a Connection Processing System," and which is incorporated herein by reference.

DS0 connections are bi-directional and ATM connections are typically uni-directional. As a result, two virtual connections in opposing directions will typically be required for each DS0. Those skilled in the art will appreciate how this can be accomplished in the context of the invention. For example, the cross-connect can be provisioned with a second set of VPI/VCIs in the opposite direction as the original set of VPI/VCIs. For each call, ATM interworking multiplexers would be configured to invoke automatically this second VPI/VCI to provide a bi-directional virtual connection to match the bi-directional DS0 on the call.

In some embodiments, it may be desirable to incorporate digital signal processing capabilities at the DS0 level. For example, in the present invention, digital signal processing is used to detect the call trigger. It may also be desired to apply echo cancellation or encryption to selected DS0 circuits. In these embodiments, a signal processor **914** would be included either separately (as shown) or as a part of the DS0 interface **912**. The signaling processor **922** would be configured to send control messages to the ATM interworking mux **902** to implement particular features on particular DS0 circuits.

FIG. **10** shows another embodiment of an ATM interworking multiplexer (mux) **1002** that is suitable for the present invention. The ATM interworking mux **1002** has a control interface **1004**, an STM-N electrical/optical (E/O) interface **1006**, an E3 interface **1008**, an E1 interface **1010**, an E0 interface **1012**, a signal processor **1014**, an ATM adaptation layer (AAL) **1016**, an STM-M electrical/optical (E/O) interface **1018**, and a digital private network signaling system (DPNSS) interface **1020**.

The control interface **1004** accepts control messages from the signaling processor **1022**. In particular, the control interface **1004** identifies E0 connections and virtual connection assignments in the control messages from the signaling processor **1022**. These assignments are provided to the AAL **1016** for implementation.

The STM-N E/O interface **1006**, the E3 interface **1008**, the E1 interface **1010**, the E0 interface **1012**, and the DPNSS interface **1020** each can accept calls, including user communications, from a second communication device **1024**. Likewise, the STM-M E/O interface **1018** can accept calls, including user communications, from a third communication device **1026**.

The STM-N E/O interface **1006** accepts STM-N electrical or optical formatted communication signals and converts the communication signals from the STM-N electrical or STM-N optical format to the E3 format. The E3 interface **1008** accepts communication signals in the E3 format and converts the communication signals to the E1 format. The E3 interface **1008** can accept E3s from the STM-N E/O interface **1006** or from an external connection. The E1 interface **1010** accepts the communication signals in the E1 format and converts the communication signals to the E0 format. The E1 interface **1010** can accept E1s from the STM-N E/O interface **1006** or the E3 interface **1008** or from an external connection. The E0 interface **1012** accepts communication signals in the E0 format and provides an interface to the AAL **1016**. The DPNSS interface **1020** accepts communication signals in the DPNSS format and converts the communication signals to the E0 format. In addition, each interface may transmit signals in a like manner to the communication device **1024**.

The STM-M E/O interface **1018** is operational to accept ATM cells from the AAL **1016** and to transmit the ATM cells over the connection to the communication device **1026**. The STM-M E/O interface **1018** may also accept ATM cells in the STM-M E/O format and transmit them to the AAL **1016**.

The AAL **1016** comprises both a convergence sublayer and a segmentation and reassembly (SAR) sublayer. The AAL **1016** is operational to accept call origination device information in the E0 format from the E0 interface **1012** and to convert the call origination device information into ATM cells.

The AAL **1016** obtains from the control interface **1004** the virtual path identifier and the virtual channel identifier for each call connection. The AAL **1016** also obtains the identity of each call. The AAL **1016** then transfers the call origination device information between the identified E0 and the identified ATM virtual connection. An acknowledgment that the assignments have been implemented may be sent back to the signaling processor **1022** if desired. If desired, the AAL **1016** can be configured to accept control messages through the control interface **1004** for Nx64 calls.

As discussed above, the ATM interworking mux **1002** also handles calls in the opposite direction, that is, in the direction from the STM-M E/O interface **1018** to the E0 interface **1012**, including calls exiting from the E1 interface **1010**, the E3 interface **1008**, the STM-N E/O interface **1006**, and the DPNSS interface **1020**. For this traffic, the VPI/VCI has been selected already and the traffic has been routed

through the cross-connect (not shown). As a result, the AAL **1016** only needs to identify the pre-assigned E0 for the selected VPI/VCI. This can be accomplished through a look-up table. In alternative embodiments, the signaling processor **1022** can provide this VPI/VCI assignment through the control interface **1004** to the AAL **1016**.

E0 connections are bi-directional and ATM connections typically are uni-directional. As a result, two virtual connections in opposing directions typically will be required for each E0. Those skilled in the art will appreciate how this can be accomplished in the context of the invention. For example, the cross-connect can be provisioned with a second set of VPI/VCIs in the opposite direction as the original set of VPI/VCIs. For each call, ATM interworking multiplexers would be configured to automatically invoke this second VPI/VCI to provide a bi-directional virtual connection to match the bi-directional E0 on the call.

In some instances, it may be desirable to incorporate digital signal processing capabilities at the E0 level. For example, in the present invention, digital signal processing is used to detect the call trigger. Also, it may be desirable apply echo cancellation. In these embodiments, a signal processor **1014** would be included either separately (as shown) or as a part of the E0 interface **1012**. The signaling processor **1022** would be configured to send control messages to the ATM interworking mux **1002** to implement particular features on particular circuits.

The Signaling Processor

The signaling processor is referred to as a call/connection manager (CCM), and it receives and processes telecommunications call signaling and control messages to select connections that establish communication paths for calls. In the preferred embodiment, the CCM processes SS7 signaling to select connections for a call. CCM processing is described in a U.S. patent application having attorney docket number 1148, which is entitled "Telecommunication System," which is assigned to the same assignee as this patent application, and which is incorporated herein by reference.

In addition to selecting connections, the CCM performs many other functions in the context of call processing. It not only can control routing and select the actual connections, but it can also validate callers, control echo cancelers, generate billing information, invoke intelligent network functions, access remote databases, manage traffic, and balance network loads. One skilled in the art will appreciate how the CCM described below can be adapted to operate in the above embodiments.

FIG. **11** depicts a version of the CCM. Other versions are also contemplated. In the embodiment of FIG. **11**, the CCM **1102** controls an ATM interworking multiplexer (mux) that performs interworking of DS0s and VPI/VCIs. However, the CCM may control other communications devices and connections in other embodiments.

The CCM **1102** comprises a signaling platform **1104**, a control platform **1106**, and an application platform **1108**. Each of the platforms **1104**, **1106**, and **1108** is coupled to the other platforms.

The signaling platform **1104** is externally coupled to the SS7 systems—in particular to systems having a message transfer part (MTP), an ISDN user part (ISUP), a signaling connection control part (SCCP), an intelligent network application part (INAP), and a transaction capabilities application part (TCAP). The control platform **1106** is externally coupled to a mux control, an echo control, a resource control, billing, and operations.

The signaling platform **1104** comprises MTP levels 1–3, ISUP, TCAP, SCCP, and INAP functionality and is operational to transmit and receive the SS7 messages. The ISUP, SCCP, INAP, and TCAP functionality use MTP to transmit and receive the SS7 messages. Together, this functionality is referred as an "SS7 stack," and it is well known. The software required by one skilled in the art to configure an SS7 stack is commercially available, for example, from the Trillium company.

The control platform **1106** is comprised of various external interfaces including a mux interface, an echo interface, a resource control interface, a billing interface, and an operations interface. The mux interface exchanges messages with at least one mux. These messages comprise DS0 to VPI/VCI assignments, acknowledgments, and status information. The echo control interface exchanges messages with echo control systems. Messages exchanged with echo control systems might include instructions to enable or disable echo cancellation on particular DS0s, acknowledgments, and status information.

The resource control interface exchanges messages with external resources. Examples of such resources are devices that implement continuity testing, encryption, compression, tone detection/transmission, voice detection, and voice messaging. The messages exchanged with resources are instructions to apply the resource to particular DS0s, acknowledgments, and status information. For example, a message may instruct a continuity testing resource to provide a loopback or to send and detect a tone for a continuity test.

The billing interface transfers pertinent billing information to a billing system. Typical billing information includes the parties to the call, time points for the call, and any special features applied to the call. The operations interface allows for the configuration and control of the CCM **1102**. One skilled in the art will appreciate how to produce the software for the interfaces in the control platform **1106**.

The application platform **1108** is functional to process signaling information from the signaling platform **1104** in order to select connections. The identity of the selected connections are provided to the control platform **1106** for the mux interface. The application platform **1108** is responsible for validation, translation, routing, call control, exceptions, screening, and error handling. In addition to providing the control requirements for the mux, the application platform **1108** also provides requirements for echo control and resource control to the appropriate interface of the control platform **1106**. In addition, the application platform **1108** generates signaling information for transmission by the signaling platform **1104**. The signaling information might be ISUP, INAP, or TCAP messages to external network elements. Pertinent information for each call is stored in a call control block (CCB) for the call. The CCB can be used for tracking and billing the call.

The application platform **1108** operates in general accord with the Basic Call Model (BCM) defined by the ITU. An instance of the BCM is created to handle each call. The BCM includes an originating process and a terminating process. The application platform **1108** includes a service switching function (SSF) that is used to invoke the service control function (SCF). Typically, the SCF is contained in a service control point (SCP). The SCF is queried with TCAP or INAP messages. The originating or terminating processes will access remote databases with intelligent network (IN) functionality via the SSF function.

Software requirements for the application platform **1108** can be produced in specification and description language (SDL) defined in ITU-T Z.100. The SDL can be converted into C code. Additional C and C++ code can be added as required to establish the environment.

The CCM **1102** can be comprised of the above-described software loaded onto a computer. The computer can be an Integrated Micro Products (IMP) FT-Sparc 600 using the Solaris operating system and conventional database systems. It may be desirable to utilize the multi-threading capability of a Unix operating system.

From FIG. **11**, it can be seen that the application platform **1108** processes signaling information to control numerous systems and facilitate call connections and services. The SS7 signaling is exchanged with external components through the signaling platform **1104**, and control information is exchanged with external systems through the control platform **1106**. Advantageously, the CCM **1102** is not integrated into a switch CPU that is coupled to a switching matrix. Unlike an SCP, the CCM **1102** is capable of processing ISUP messages independently of TCAP queries.

SS7 Message Designations

SS7 messages are well known. Designations for various SS7 messages commonly are used. Those skilled in the art are familiar with the following message designations:

ACM	Address Complete Message
ANM	Answer Message
BLO	Blocking
BLA	Blocking Acknowledgment
CPG	Call Progress
CRG	Charge Information
CGB	Circuit Group Blocking
CGBA	Circuit Group Blocking Acknowledgment
GRS	Circuit Group Reset
GRA	Circuit Group Reset Acknowledgment
CGU	Circuit Group Unblocking
CGUA	Circuit Group Unblocking Acknowledgment
CQM	Circuit Group Query
CQR	Circuit Group Query Response
CRM	Circuit Reservation Message
CRA	Circuit Reservation Acknowledgment
CVT	Circuit Validation Test
CVR	Circuit Validation Response
CFN	Confusion
COT	Continuity
CCR	Continuity Check Request
EXM	Exit Message
INF	Information
INR	Information Request
IAM	Initial Address
LPA	Loop Back Acknowledgment
PAM	Pass Along
REL	Release
RLC	Release Complete
RSC	Reset Circuit
RES	Resume
SUS	Suspend
UBL	Unblocking
UBA	Unblocking Acknowledgment
UCIC	Unequipped Circuit Identification Code.

CCM Tables

Call processing typically entails two aspects. First, an incoming or "originating" connection is recognized by an originating call process. For example, the initial connection that a call uses to enter a network is the originating connection in that network. Second, an outgoing or "terminating" connection is selected by a terminating call process. For example, the terminating connection is coupled to the originating connection in order to extend the call through the network. These two aspects of call processing are referred to as the originating side of the call and the terminating side of the call.

FIG. **12** depicts a data structure used by the application platform **1108** to execute the BCM. This is accomplished through a series of tables that point to one another in various ways. The pointers are typically comprised of next function and next index designations. The next function points to the next table, and the next index points to an entry or a range of entries in that table. The data structure has a trunk circuit table **1202**, a trunk group table **1204**, an exception table **1206**, an ANI table **1208**, a called number table **1210**, and a routing table **1212**.

The trunk circuit table **1202** contains information related to the connections. Typically, the connections are DS0 or ATM connections. Initially, the trunk circuit table **1202** is used to retrieve information about the originating connection. Later, the table is used to retrieve information about the terminating connection. When the originating connection is being processed, the trunk group number in the trunk circuit table **1202** points to the applicable trunk group for the originating connection in the trunk group table **1204**.

The trunk group table **1204** contains information related to the originating and terminating trunk groups. When the originating connection is being processed, the trunk group table **1204** provides information relevant to the trunk group for the originating connection and typically points to the exception table **1206**.

The exception table **1206** is used to identify various exception conditions related to the call that may influence the routing or other handling of the call. Typically, the exception table **1206** points to the ANI table **1208**. Although, the exception table **1206** may point directly to the trunk group table **1204**, the called number table **1210**, or the routing table **1212**.

The ANI-table **1208** is used to identify any special characteristics related to the caller's number. The caller's number is commonly known as automatic number identification (ANI). The ANI table **1208** typically points to the called number table **1210**. Although, the ANI table **1208** may point directly to the trunk group table **1204** or the routing table **1212**.

The called number table **1210** is used to identify routing requirements based on the called number. This will be the case for standard telephone calls. The called number table **1210** typically points to the routing table **1212**. Although, it may point to the trunk group table **1204**.

The routing table **1212** has information relating to the routing of the call for the various connections. The routing table **1212** is entered from a pointer in either the exception table **1206**, the ANI table **1208**, or the called number table **1210**. The routing table **1212** typically points to a trunk group in the trunk group table **1204**.

When the exception table **1206**, the ANI table **1208**, the called number table **1210**, or the routing table **1212** point to the trunk group table **1204**, they effectively select the terminating trunk group. When the terminating connection is being processed, the trunk group number in the trunk group table **1204** points to the trunk group that contains the applicable terminating connection in the trunk circuit table **1204**.

The terminating trunk circuit is used to extend the call. The trunk circuit is typically a VPI/VCI or a DS0. Thus it can be seen that by migrating through the tables, a terminating connection can be selected for a call.

FIG. **13** is an overlay of FIG. **12**. The tables from FIG. **12** are present, but for clarity, their pointers have been omitted. FIG. **13** illustrates additional tables that can be accessed from the tables of FIG. **12**. These include a CCM ID table **1302**, a treatment table **1304**, a query/response table **1306**, and a message table **1308**.

The CCM ID table **1302** contains various CCM SS7 point codes. It can be accessed from the trunk group table **1204**, and it points back to the trunk group table **1204**.

The treatment table **1304** identifies various special actions to be taken in the course of call processing. This will typically result in the transmission of a release message (REL) and a cause value. The treatment table **1304** can be accessed from the trunk circuit table **1202**, the trunk group table **1204**, the exception table **1206**, the ANI table **1208**, the called number table **1210**, the routing table **1212**, and the query/response table **1306**.

The query/response table **1306** has information used to invoke the SCF. It can be accessed by the trunk group table **1204**, the exception table **1206**, the ANI table **1208**, the called number table **1210**, and the routing table **1212**. It points to the trunk group table **1204**, the exception table **1206**, the ANI table **1208**, the called number table **1210**, the routing table **1212**, and the treatment table **1304**.

The message table **1308** is used to provide instructions for messages from the termination side of the call. It can be accessed by the trunk group table **1204** and points to the trunk group table **1204**.

FIGS. **14–21** depict examples of the various tables described above. FIG. **14** depicts an example of the trunk circuit table. Initially, the trunk circuit table is used to access information about the originating circuit. Later in the processing, it is used to provide information about the terminating circuit. For originating circuit processing, the associated point code is used to enter the table. This is the point code of the switch or CCM associated with the originating circuit. For terminating circuit processing, the trunk group number is used to enter the table.

The table also contains the circuit identification code (CIC). The CIC identifies the circuit which is typically a DS0 or a VPI/VCI. Thus, the invention is capable of mapping the SS7 CICs to the ATM VPI/VCI. If the circuit is ATM, the virtual path (VP) and the virtual channel (VC) also can be used for identification. The group member number is a numeric code that is used for terminating circuit selection. The hardware identifier identifies the location of the hardware associated with the originating circuit. The echo canceler (EC) identification (ID) entry identifies the echo canceler for the originating circuit.

The remaining fields are dynamic in that they are filled during call processing. The echo control entry is filled based on three fields in signaling messages: the echo suppresser indicator in the IAM or CRM, the echo control device indicator in the ACM or CPM, and the information transfer capability in the IAM. This information is used to determine if echo control is required on the call. The satellite indicator is filled with the satellite indicator in the IAM or CRM. It may be used to reject a call if too many satellites are used. The circuit status indicates if the given circuit is idle, blocked, or not blocked. The circuit state indicates the current state of the circuit, for example, active or transient. The time/date indicates when the idle circuit went idle.

FIG. **15** depicts an example of the trunk group table. During origination processing, the trunk group number from the trunk circuit table is used to key into the trunk table. Glare resolution indicates how a glare situation is to be resolved. Glare is dual seizure of the same circuit. If the glare resolution entry is set to “even/odd,” the network element with the higher point code controls the even circuits, and the network element with the lower point code controls the odd circuits. If the glare resolution entry is set to “all,” the CCM controls all of the circuits. If the glare resolution entry is set to “none,” the CCM yields. The continuity control entry lists the percent of calls requiring continuity tests on the trunk group.

The common language location identifier (CLLI) entry is a Bellcore standardized entry. The satellite trunk group entry indicates that the trunk group uses a satellite. The satellite trunk group entry is used in conjunction with the satellite indicator field described above to determine if the call has used too many satellite connections and, therefore, must be rejected. The service indicator indicates if the incoming message is from a CCM (ATM) or a switch (TDM). The outgoing message index (OMI) points to the message table so that outgoing messages can obtain parameters. The associated number plan area (NPA) entry identifies the area code.

Selection sequence indicates the methodology that will be used to select a connection. The selection sequence field designations tell the trunk group to select circuits based on the following: least idle, most idle, ascending, descending, clockwise, and counterclockwise. The hop counter is decremented from the IAM. If the hop counter is zero, the call is released. Automatic congestion control (ACC) active indicates whether or not congestion control is active. If automatic congestion control is active, the CCM may release the call. During termination processing, the next function and index are used to enter the trunk circuit table.

FIG. **16** depicts an example of the exception table. The index is used as a pointer to enter the table. The carrier selection identification (ID) parameter indicates how the caller reached the network and is used for routing certain types of calls. The following are used for this field: spare or no indication, selected carrier identification code presubscribed and input by the calling party, selected carrier identification code presubscribed and not input by the calling party, selected carrier identification code presubscribed and no indication of input by the calling party, and selected carrier identification code not presubscribed and input by the calling party. The carrier identification (ID) indicates the network that the caller wants to use. This is used to route calls directly to the desired network. The called party number nature of address differentiates between 0+ calls, 1+ calls, test calls, and international calls. For example, international calls might be routed to a pre-selected international carrier.

The called party “digits from” and “digits to” focus further processing unique to a defined range of called numbers. The “digits from” field is a decimal number ranging from 1–15 digits. It can be any length and, if filled with less than 15 digits, is filled with 0s for the remaining digits. The “digits to” field is a decimal number ranging from 1–15 digits. It can be any length and, if filled with less than 15 digits, is filled with 9s for the remaining digits. The next function and next index entries point to the next table which is typically the ANI table.

FIG. **17** depicts an example of the ANI table. The index is used to enter the fields of the table. The calling party category differentiates among types of calling parties, for example, test calls, emergency calls, and ordinary calls. The calling party\charge number entry nature of address indicates how the ANI is to be obtained. The following is the table fill that is used in this field: unknown, unique subscriber numbers, ANI not available or not provided, unique national number, ANI of the called party included, ANI of the called party not included, ANI of the called party includes national number, non-unique subscriber number, non-unique national number, non-unique international number, test line test code, and all other parameter values.

The “digits from” and “digits to” focus further processing unique to ANI within a given range. The data entry indicates if the ANI represents a data device that does not need echo control. Originating line information (OLI) differentiates among ordinary subscriber, multiparty line, ANI failure, station level rating, special operator handling, automatic

identified outward dialing, coin or non-coin call using database access, 800\888 service call, coin, prison/inmate service, intercept (blank, trouble, and regular), operator handled call, outward wide area telecommunications service, telecommunications relay service (TRS), cellular services, private paystation, and access for private virtual network types of service. The next function and next index point to the next table which is typically the called number table.

FIG. **18** depicts an example of the called number table. The index is used to enter the table. The called number nature of address entry indicates the type of dialed number, for example, national versus international. The "digits from" and "digits to" entries focus further processing unique to a range of called numbers. The processing follows the processing logic of the "digits from" and "digits to" fields in FIG. **16**. The next function and next index point to the next table which is typically the routing table.

FIG. **19** depicts an example of the routing table. The index is used to enter the table. The transit network selection (TNS) network identification (ID) plan indicates the number of digits to use for the CIC. The transit network selection "digits from" and "digits to" fields define the range of numbers to identify an international carrier. The circuit code indicates the need for an operator on the call. The next function and next index entries in the routing table are used to identify a trunk group. The second and third next function/index entries define alternate routes. The third next function entry can also point back to another set of next functions in the routing table in order to expand the number of alternate route choices. The only other entries allowed are pointers to the treatment table. If the routing table points to the trunk group table, then the trunk group table typically points to a trunk circuit in the trunk circuit table. The yield from the trunk circuit table is the terminating connection for the call.

It can be seen from FIGS. **14–19** that the tables can be configured and relate to one another in such a way that call processes can enter the trunk circuit table for the originating connection and can traverse through the tables by keying on information and using pointers. The yield of the tables is typically a terminating connection identified by the trunk circuit table. In some cases, treatment is specified by the treatment table instead of a connection. If, at any point during the processing, a trunk group can be selected, processing may proceed directly to the trunk group table for terminating circuit selection. For example, it may be desirable to route calls from a particular ANI over a particular set of trunk groups. In this case, the ANI table would point directly to the trunk group table, and the trunk group table would point to the trunk circuit table for a terminating circuit. The default path through the tables is: trunk circuit, trunk group, exception, ANI, called number, routing, trunk group, and trunk circuit.

FIG. **20** depicts an example of the treatment table. Either the index or the message received cause number are filled and are used to enter the table. If the index is filled and used to enter the table, the general location, coding standard, and cause value indicator are used to generate an SS7 REL. The message received cause value entry is the cause value in a received SS7 message. If the message received cause value is filled and used to enter the table, then the cause value from that message is used in a REL from the CCM. The next function and next index point to the next table.

FIG. **21** depicts an example of the message table. This table allows the CCM to alter information in outgoing messages. Message type is used to enter the table, and it represents the outgoing standard SS7 message type. The parameter is the pertinent parameter within the outgoing SS7 message. The indexes point to various entries in the trunk group table and determine if parameters can be unchanged, omitted, or modified in the outgoing messages.

Those skilled in the art will appreciate that variations from the specific embodiments disclosed above are contemplated by the invention. The invention should not be restricted to the above embodiments, but should be measured by the following claims.

What is claimed is:

1. A communication system comprising:

a signaling processor configured to receive and process Signaling System Seven (SS7) signaling for a call, and in response, to generate and transfer control messaging indicating identifiers that are used for routing; and

a service platform system configured to receive the control messaging, and in response, to exchange communications that include the identifiers to interact with a caller to provide a service.

2. The communication system of claim **1** wherein the service platform system is configured to generate and transfer a service complete message after interacting with the caller to provide the service.

3. The communication system of claim **2** wherein the signaling processor is configured to receive and process the service complete message, and in response, to generate and transfer a routing instruction for the call.

4. The communication system of claim **1** wherein the service platform system is configured to convert the communications between a time division multiplex format and another format where the communications include the identifiers.

5. The communication system of claim **1** wherein the service comprises a calling card service.

6. The communication system of claim **1** wherein the service comprises a teleconference service.

7. The communication system of claim **1** wherein the service comprises a voice mail service.

8. The communication system of claim **1** wherein the service comprises a call forwarding service.

9. The communication system of claim **1** wherein the service includes voice recognition processing.

10. The communication system of claim **1** wherein the service includes tone detection processing.

11. A method of operating a communication system, the method comprising:

in a signaling processor, receiving and processing Signaling System Seven (SS7) signaling for a call, and in response, generating and transferring control messaging indicating identifiers that are used for routing; and

in a service platform system, receiving the control messaging, and in response, exchanging communications that include the identifiers to interact with a caller to provide a service.

12. The method of claim **11** further comprising, in the service platform system, generating and transferring a service complete message after interacting with the caller to provide the service.

13. The method of claim **12** further comprising, in the signaling processor, receiving and processing the service complete message, and in response, generating and transferring a routing instruction for the call.

14. The method of claim **11** wherein exchanging the communications that include the identifiers comprises converting the communications between a time division multi-

plex format and another format where the communications include the identifiers.

15. The method of claim **11** wherein the service comprises a calling card service.

16. The method of claim **11** wherein the service comprises a teleconference service.

17. The method of claim **11** wherein the service comprises a voice mail service.

18. The method of claim **11** wherein the service comprises a call forwarding service.

19. The method of claim **11** wherein the service includes voice recognition processing.

20. The method of claim **11** wherein the service includes tone detection processing.

* * * * *

EXHIBIT I

US007286561B2

(12) **United States Patent**
Christie

(10) **Patent No.: US 7,286,561 B2**
(45) **Date of Patent: *Oct. 23, 2007**

(54) **METHOD SYSTEM AND APPARATUS FOR TELECOMMUNICATIONS CONTROL**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 497 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **10/633,798**

(22) Filed: **Aug. 4, 2003**

(65) **Prior Publication Data**

US 2004/0037328 A1 Feb. 26, 2004

Related U.S. Application Data

(63) Continuation of application No. 09/082,040, filed on May 20, 1998, now Pat. No. 6,643,282, which is a continuation of application No. 08/568,551, filed on Dec. 7, 1995, now Pat. No. 5,825,780, which is a continuation of application No. 08/238,605, filed on May 5, 1994, now abandoned.

(51) **Int. Cl.**
H04J 3/16 (2006.01)
H04J 3/22 (2006.01)

(52) **U.S. Cl.** **370/466**; 370/410

(58) **Field of Classification Search** 370/389, 370/392, 401, 398, 399, 410–422, 426, 466
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,720,850 A 1/1988 Oberlander et al.
4,730,312 A 3/1988 Johnson et al.
4,736,364 A 4/1988 Basso et al.
4,748,658 A 5/1988 Gopal et al.
4,757,526 A 7/1988 Foster et al.
4,763,317 A 8/1988 Lehman et al.
4,853,955 A 8/1989 Thorn et al.
4,970,721 A 11/1990 Aczel et al.
4,991,169 A 2/1991 Davis et al.
5,003,584 A 3/1991 Benyacar et al.
5,042,027 A 8/1991 Takase et al.

(Continued)

FOREIGN PATENT DOCUMENTS

EP 0439098 7/1991

(Continued)

OTHER PUBLICATIONS

Kuribayashi, Shin-Ichi; Advanced Signaling Protocol for Broadband ISDN Services; Electronics and Communications in Japan; Part 1, vol. 78, No. 1, pp. 1-12.

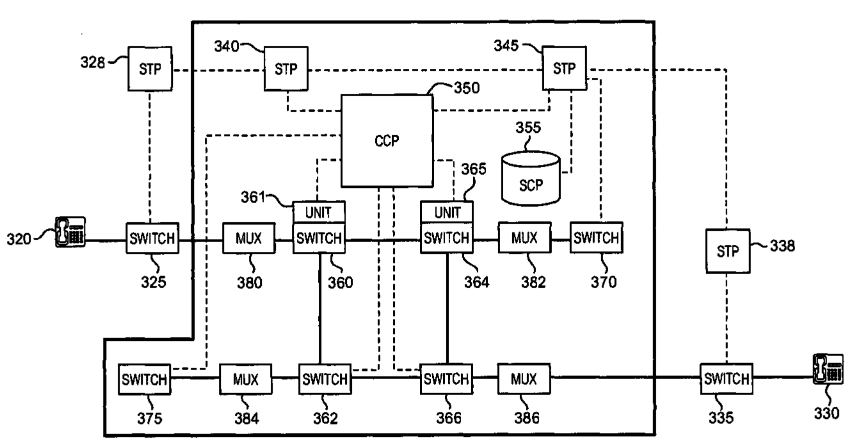
(Continued)

Primary Examiner—Ajit Patel

(57) **ABSTRACT**

The present invention includes a method, system, and apparatus for providing communication control. The invention includes a method in which signaling is processed externally to a switch before it is applied by the network elements. The processor is able to select network characteristics and signal the network elements based the selections. A network employing the processing method is also included, as well as a signaling system that employs the processing method.

20 Claims, 8 Drawing Sheets



U.S. PATENT DOCUMENTS

5,048,081	A		9/1991	Gavaras et al.
5,051,983	A		9/1991	Kammerl
5,089,954	A		2/1992	Rago
5,115,427	A		5/1992	Johnson, Jr. et al.
5,185,743	A		2/1993	Murayama et al.
5,204,857	A		4/1993	Obara
5,251,255	A		10/1993	Epley
5,258,979	A		11/1993	Oomuro et al.
5,268,895	A		12/1993	Topper
5,271,010	A		12/1993	Miyake et al.
5,274,635	A		12/1993	Rahman et al.
5,278,972	A		1/1994	Baker et al.
5,282,244	A		1/1994	Fuller et al.
5,289,472	A		2/1994	Cho
5,291,492	A		3/1994	Andrews et al.
5,327,421	A		7/1994	Hiller et al.
5,339,318	A		8/1994	Tanaka et al.
5,345,443	A		9/1994	D'Ambrogio et al.
5,345,445	A		9/1994	Hiller et al.
5,345,446	A		9/1994	Hiller et al.
5,363,433	A		11/1994	Isono
5,375,124	A		12/1994	D'Ambrogio et al.
5,377,186	A		12/1994	Wegner et al.
5,392,402	A		2/1995	Robrock, II
5,420,858	A		5/1995	Marshall et al.
5,422,882	A		6/1995	Hiller et al.
5,425,090	A		6/1995	Orriss
5,428,609	A		6/1995	Eng et al.
5,434,852	A	*	7/1995	La Porta et al. 370/385
5,434,981	A		7/1995	Lenihan et al.
5,438,527	A		8/1995	Feldbaumer et al.
5,440,626	A		8/1995	Boyle et al.
5,444,713	A		8/1995	Backaus et al.
5,452,297	A		9/1995	Hiller et al.
5,452,350	A		9/1995	Reynolds et al.
5,457,684	A		10/1995	Bharucha et al.
5,469,501	A		11/1995	Otsuka
5,473,677	A		12/1995	D'Amato et al.
5,473,679	A	*	12/1995	La Porta et al. 379/201.05
5,483,527	A	*	1/1996	Doshi et al. 370/399
5,495,484	A		2/1996	Self et al.
5,509,010	A	*	4/1996	La Porta et al. 370/397
5,519,690	A		5/1996	Suzuka et al.
5,519,707	A		5/1996	Subramanian et al.
5,537,461	A		7/1996	Bridges et al.
5,541,917	A		7/1996	Farris
5,550,834	A		8/1996	D'Ambrogio et al.
5,550,914	A		8/1996	Clarke et al.
5,563,939	A		10/1996	La Porta et al.
5,568,475	A	*	10/1996	Doshi et al. 370/399
5,577,037	A		11/1996	Takatori et al.
5,579,311	A		11/1996	Chopping et al.
5,590,133	A		12/1996	Billstrom et al.
5,600,643	A		2/1997	Robrock, II
5,673,262	A		9/1997	Shimizu
5,715,239	A		2/1998	Hyodo et al.
5,765,108	A		6/1998	Martin et al.
5,793,765	A		8/1998	Boer et al.
5,825,780	A		10/1998	Christie
5,991,301	A		11/1999	Christie
6,038,606	A		3/2000	Brooks et al.
6,175,574	B1		1/2001	Lewis

FOREIGN PATENT DOCUMENTS

EP	0 559 979 A1	9/1993
EP	0935856	8/1999
HU	71152	11/1995
JP	1013534	1/1989
JP	1300738	12/1989
JP	2215247	8/1990
JP	4180324	6/1992
JP	4196635	7/1992
JP	5327751	12/1993
JP	6006320	1/1994
JP	6209365	7/1994
JP	7177061	7/1995
JP	7250099	9/1995
JP	8149137	6/1996
WO	WO9214321	8/1992
WO	WO9931855	6/1999

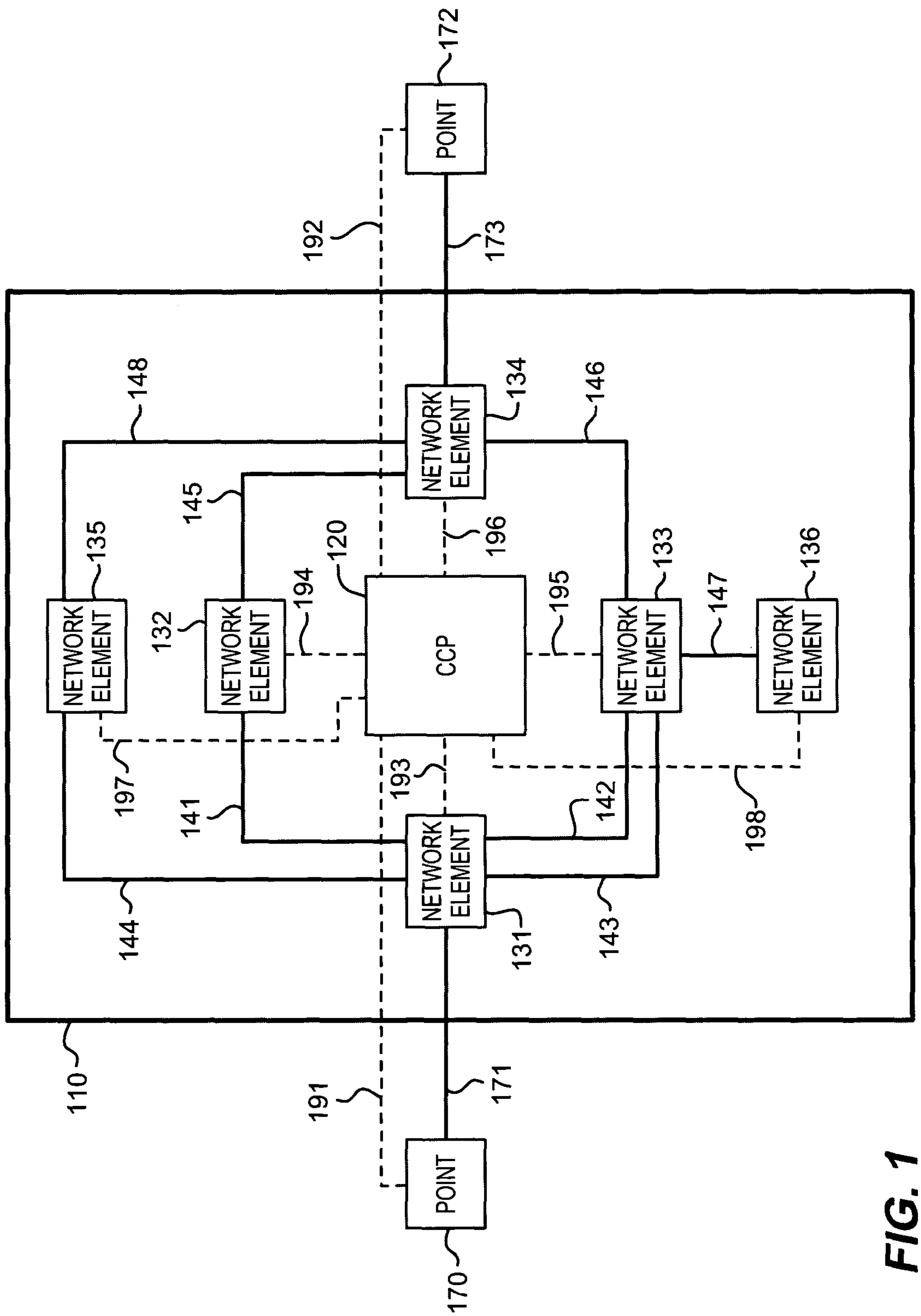
OTHER PUBLICATIONS

Hungarian office action dated Jun. 23, 1999 citing Hungarian patent No. HU170127 for Hungarian Application No. P9900232; 2 pages.

Russian office action dated Apr. 22, 2002 citing Russian patent Nos. RU2013011 and RU2007880 for Russian Application No. 99112956; 6 pages.

Hiroshi Ishii and Masatoshi Kawarasaki; B-ISDN Signalling Protocol Capabilities; NTT Telecommunication Networks Laboratories; 1989; pp. 41.2.1-41.2.5.

* cited by examiner



POINT
172
192
173
148
134
146
NETWORK ELEMENT
145
120
196
135
133
136
NETWORK ELEMENT
132
NETWORK ELEMENT
194
CCP
195
NETWORK ELEMENT
147
NETWORK ELEMENT
197
193
141
142
198
NETWORK ELEMENT
144
131
143
110
191
171
POINT
170

FIG. 1

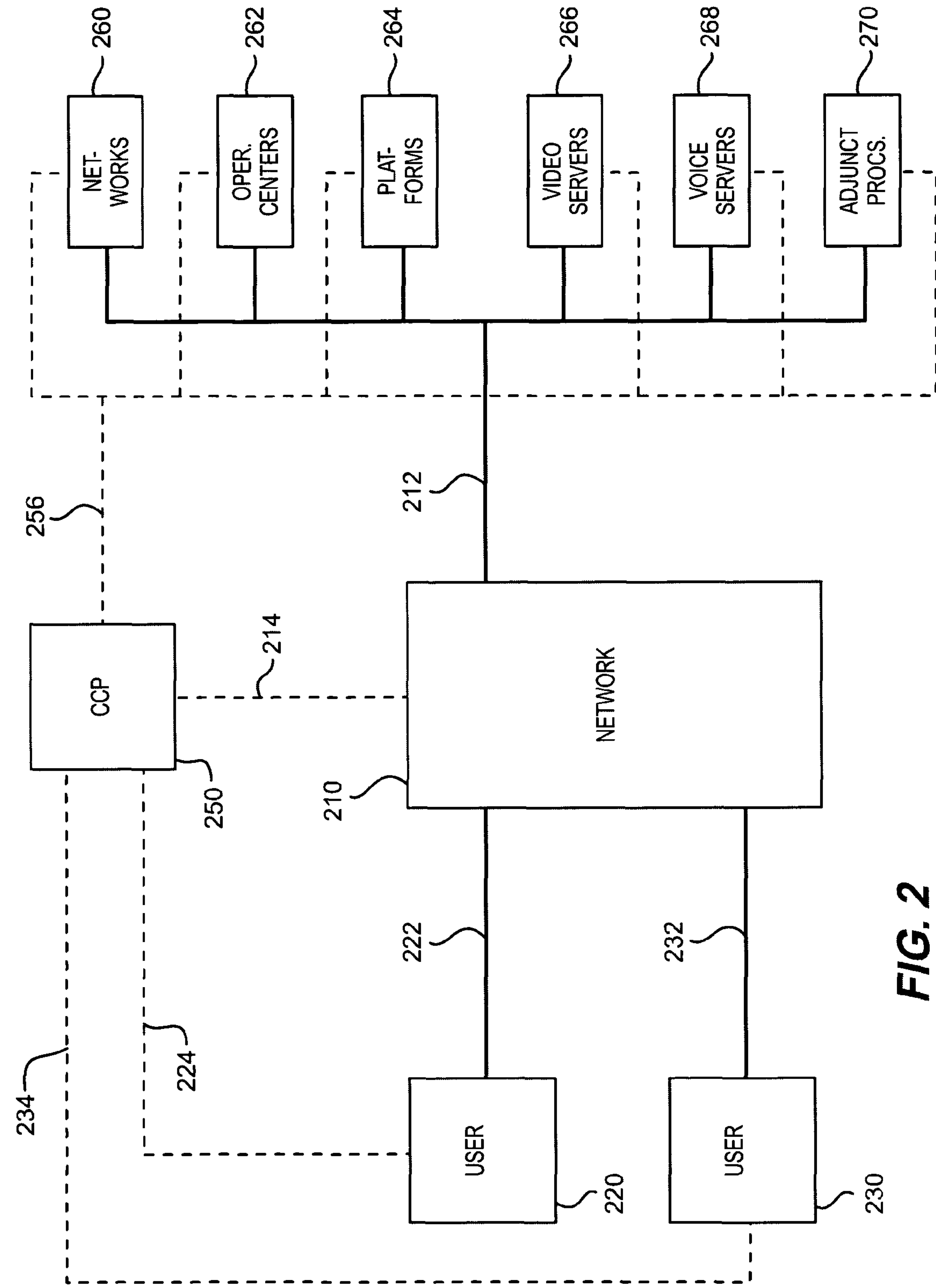

260
NET-WORKS
262
OPER. CENTERS
264
PLAT-FORMS
266
VIDEO SERVERS
268
VOICE SERVERS
270
ADJUNCT PROCS.
212
256
CCP
214
250
NETWORK
210
222
232
224
234
USER
220
USER
230

FIG. 2

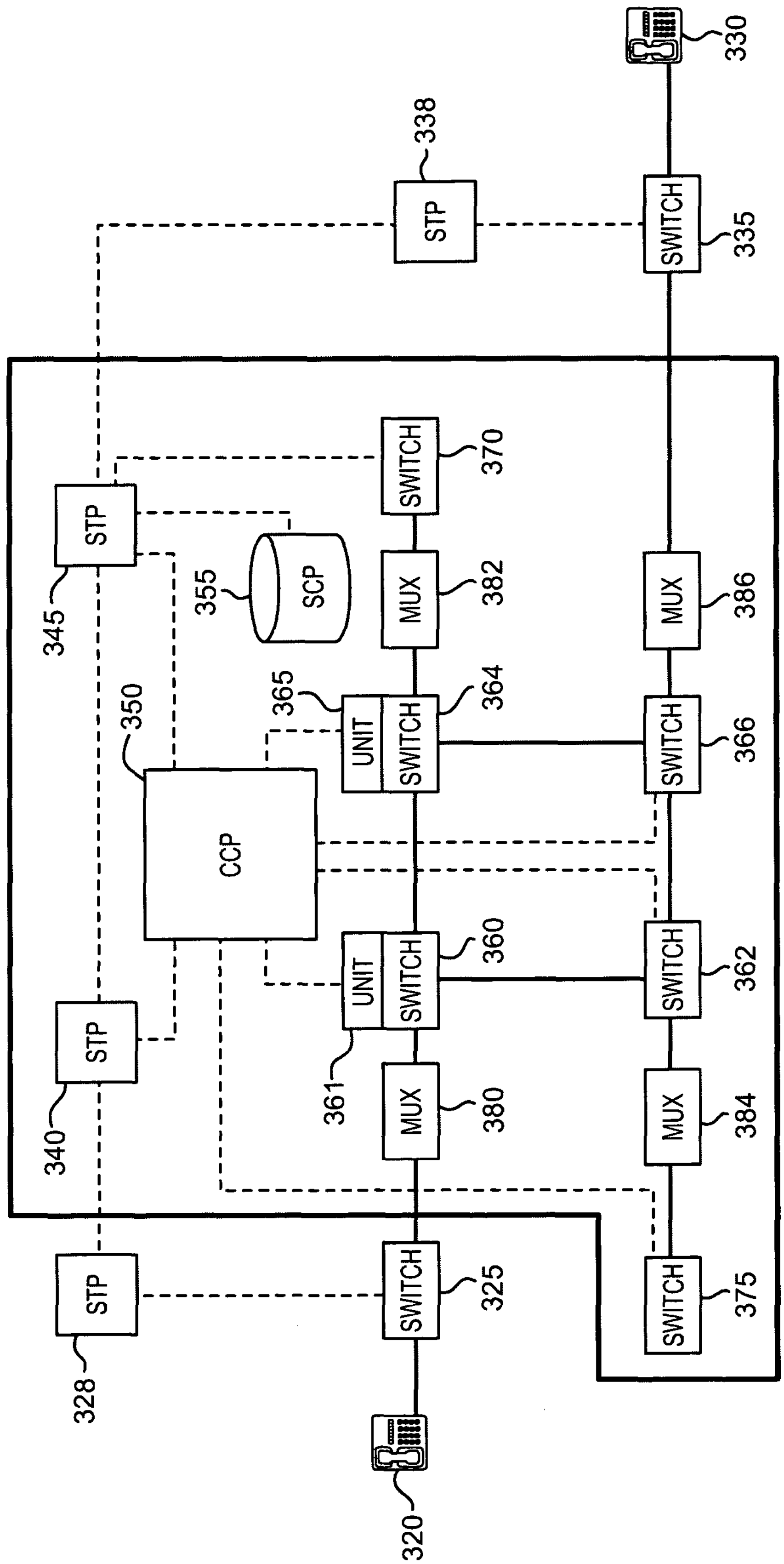

330
338
STP
SWITCH
335
SWITCH
370
STP
345
SCP
355
MUX
382
MUX
386
350
365
UNIT
SWITCH
364
SWITCH
366
CCP
UNIT
SWITCH
360
SWITCH
362
STP
340
361
MUX
380
MUX
384
STP
328
SWITCH
325
SWITCH
375
320

FIG. 3

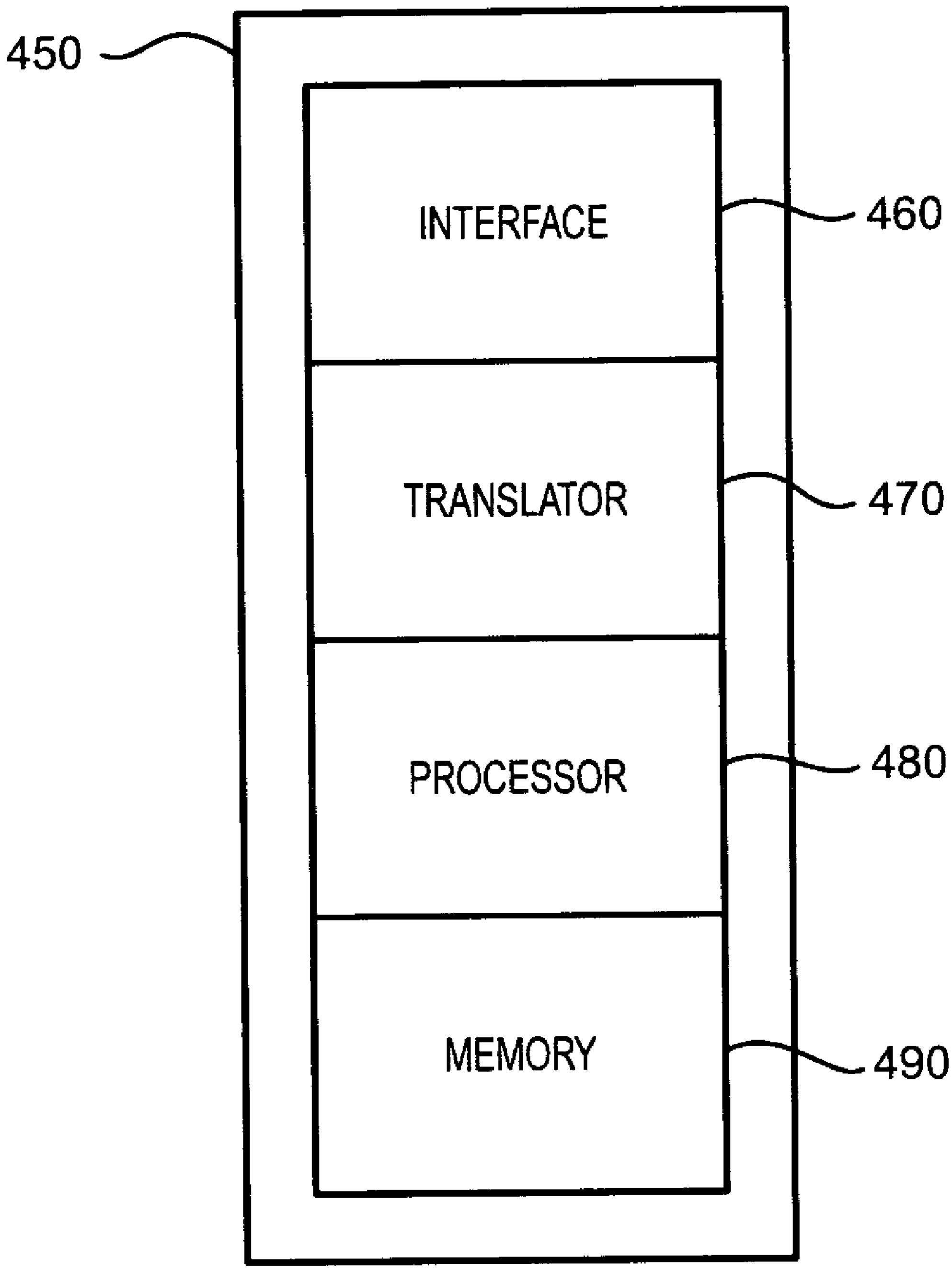


FIG. 4

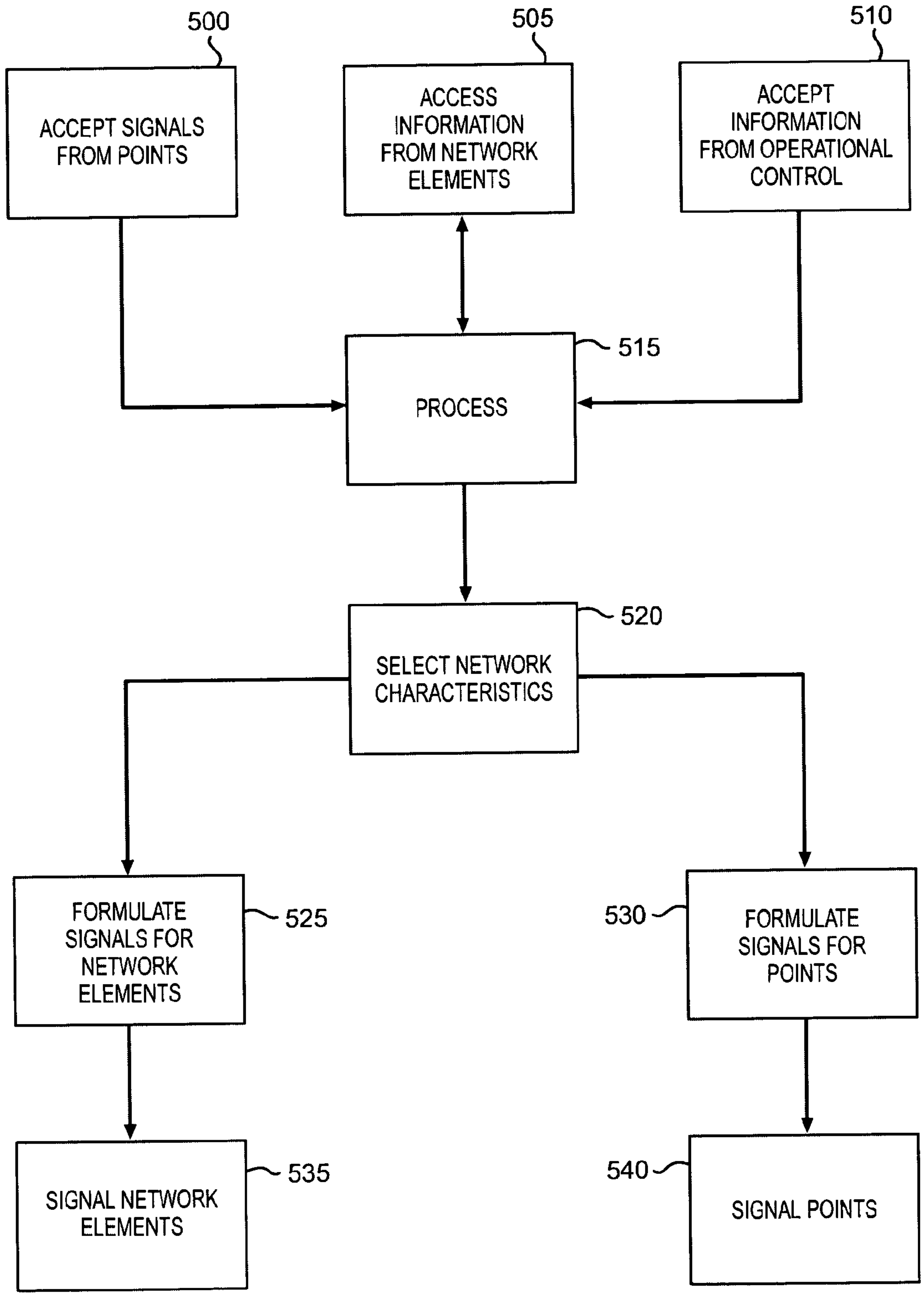

500
ACCEPT SIGNALS FROM POINTS
505
ACCESS INFORMATION FROM NETWORK ELEMENTS
510
ACCEPT INFORMATION FROM OPERATIONAL CONTROL
515
PROCESS
520
SELECT NETWORK CHARACTERISTICS
525
FORMULATE SIGNALS FOR NETWORK ELEMENTS
530
FORMULATE SIGNALS FOR POINTS
535
SIGNAL NETWORK ELEMENTS
540
SIGNAL POINTS

FIG. 5

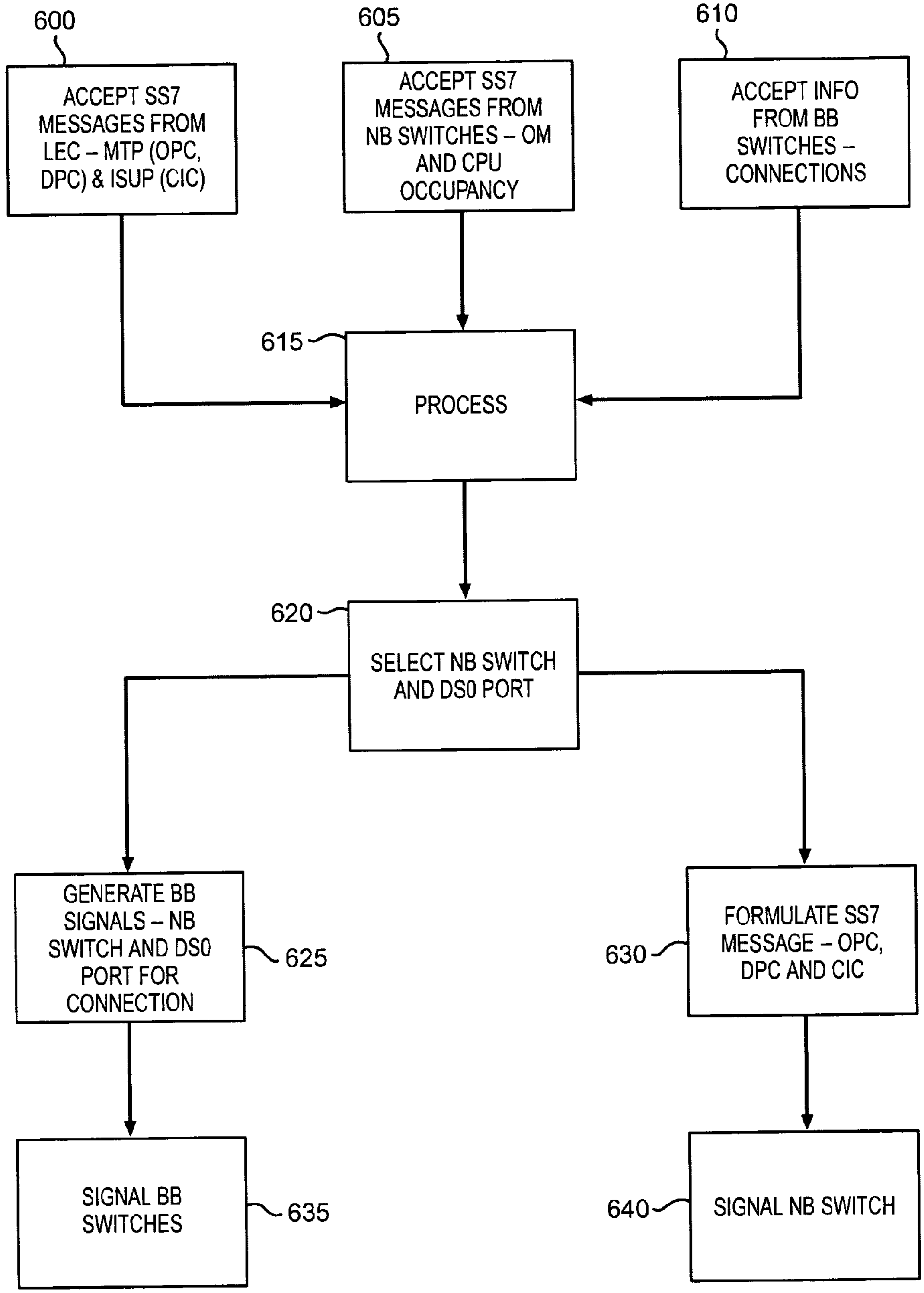

600
ACCEPT SS7 MESSAGES FROM LEC – MTP (OPC, DPC) & ISUP (CIC)
605
ACCEPT SS7 MESSAGES FROM NB SWITCHES – OM AND CPU OCCUPANCY
610
ACCEPT INFO FROM BB SWITCHES – CONNECTIONS
615
PROCESS
620
SELECT NB SWITCH AND DS0 PORT
GENERATE BB SIGNALS – NB SWITCH AND DS0 PORT FOR CONNECTION
625
630
FORMULATE SS7 MESSAGE – OPC, DPC AND CIC
SIGNAL BB SWITCHES
635
640
SIGNAL NB SWITCH

FIG. 6

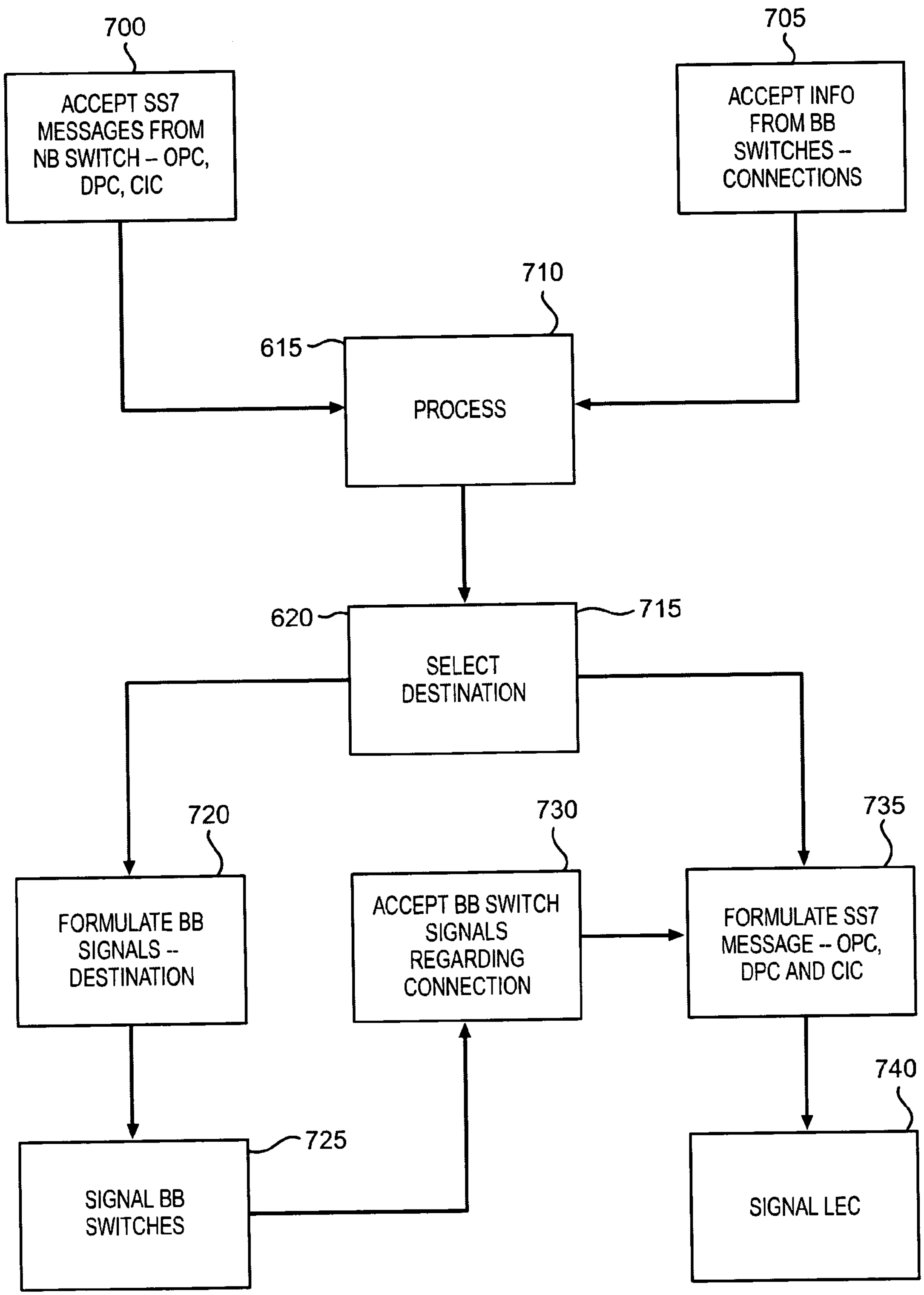

700
ACCEPT SS7 MESSAGES FROM NB SWITCH -- OPC, DPC, CIC
705
ACCEPT INFO FROM BB SWITCHES -- CONNECTIONS
710
615
PROCESS
620
715
SELECT DESTINATION
720
FORMULATE BB SIGNALS -- DESTINATION
730
ACCEPT BB SWITCH SIGNALS REGARDING CONNECTION
735
FORMULATE SS7 MESSAGE -- OPC, DPC AND CIC
725
SIGNAL BB SWITCHES
740
SIGNAL LEC

FIG. 7

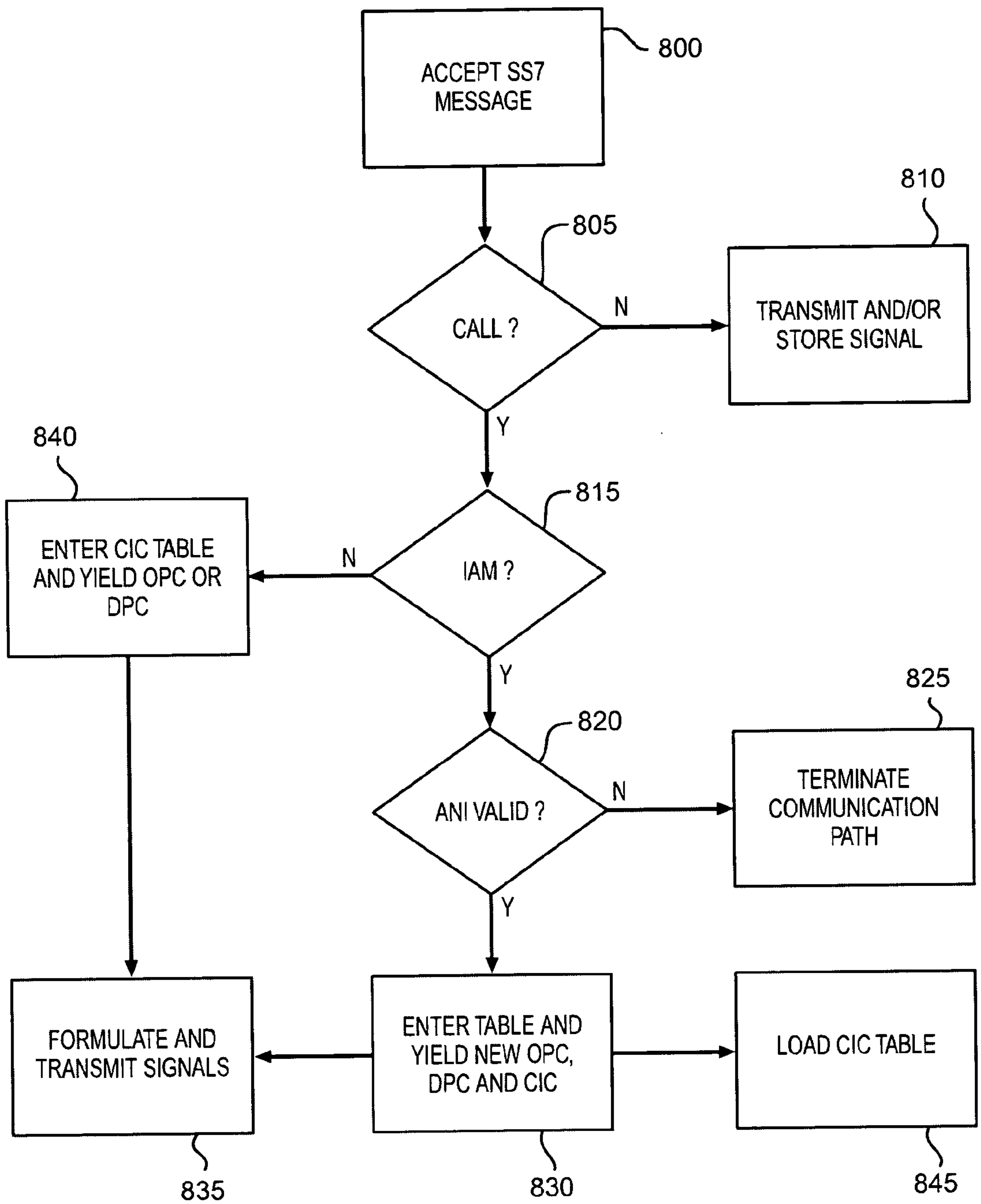

ACCEPT SS7 MESSAGE
800
CALL ?
805
N
Y
TRANSMIT AND/OR STORE SIGNAL
810
IAM ?
815
N
Y
ENTER CIC TABLE AND YIELD OPC OR DPC
840
ANI VALID ?
820
N
Y
TERMINATE COMMUNICATION PATH
825
FORMULATE AND TRANSMIT SIGNALS
835
ENTER TABLE AND YIELD NEW OPC, DPC AND CIC
830
LOAD CIC TABLE
845

FIG. 8

METHOD SYSTEM AND APPARATUS FOR TELECOMMUNICATIONS CONTROL

RELATED APPLICATIONS

This application is a continuation of application Ser. No. 09/082,040, filed on May 20, 1998, now U.S. Pat. No. 6,643,282, which is a continuation Ser. No. 08/568,551, of U.S. Pat. No. 5,825,780, filed on Dec. 7, 1995, which is a continuation of U.S. patent application Ser. No. 08/238,605, filed on May 5, 1994 and now abandoned, which are hereby incorporated by reference into this application.

FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not applicable

MICROFICHE APPENDIX

Not applicable

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to telecommunications and more specifically to communications control processing in telecommunications signaling.

2. Description of the Prior Art

Telecommunications systems establish a communications path between two or more points to allow the transfer of information between the points. The communications path typically comprises a series of connections between network elements. The network elements are typically switches. Switches provide the primary means where different connections are associated to form the communications path. Communication control is the process of setting up a communications path between the points. Communication control comprises the selection of network elements such as switches or other devices which will form part of the communications path. Communication control also comprises the selection of the connections between the network elements. Together, control also comprises the selection of the connections between the network elements. Together, the network elements and connections which are selected make up the communications path. Typically, a plurality of different network element and connection selections may be possible for any one communications path between points.

Switches control these selections. Switches select the connections that comprise the communications path. Switches also select the network elements which form an actual part of that communications path. By selecting these network elements, a switch is often selecting the next switch that will make further selections. Switches accomplish communication control.

The correspondence between communication control and a communications path is well known in the art. A common method used in communication control is signaling among switches. One method by which a first point requests a communications path to a second point is by signaling a first switch with an off-hook signal followed by dual tone multifrequency (DTMF) signals. The first switch will typically process those signals and will select other network elements such as a second switch. The first switch signals the second switch and establishes a connection between the switches. The second switch then selects the next network element, signals that network element, and establishes a connection to

that network element. This process is well known in the art. The connections and signaling thus proceed from switch to switch through the network until a communications path is established between the first and second points.

Some networks transmit signaling information from the switches to other signaling devices. In these cases, the switches typically must be modified through the use of Signaling Point (SP) hardware and software in order to convert the language of the switch into the language used by these other signaling devices. One signaling device is a Service Control Point (SCP). An SCP processes signaling queries from a switch. An SCP only answers a switch query after the switch has become a part of the communications path. SCPs support the communication control which is directed by the switch.

Additionally, signaling may pass through other signaling devices, such as Signal Transfer Points (STPs), which route the signaling. An STP is typically, a high-speed packet data switch which reads portions of the signaling information and either discards or routes the information to a network element. The signal routing operation of the STP is based on the signaling information that is specified by the switch. STPs route signaling information, but STPs do not modify or otherwise process the signaling information. An example of the above described system is Signaling System #7 (SS7) technology. Thus, signaling devices only are used to support switches in communication control.

Broadband systems, such as Asynchronous Transfer Mode (ATM) may use extensions of existing SS7 signaling to allow ATM switches to direct communication control. However, broadband systems may also utilize different communication control methods. ATM switches may transfer ATM cells which contain signaling to other ATM switches. As with the other switch types however, ATM switches also perform the dual task of communication control and forming a part of the communications path.

Some switches use API switching which employs remote central processing units (CPUs). These switches only receive switch information from the remote CPUs and not signaling. The protocols used for information transfer between the switch and the remote CPU are proprietary among vendors and are incompatible between the switches of different vendors.

Some digital cross-connect (DCS) equipment employ centralized control systems. These systems, however, only provide relatively static switching fabrics and do not respond to signaling. Instead of establishing connections in response to signaling, DCS cross-connections are established in response to network configuration needs. Network elements and connections are pre-programmed into the network and are not selected in response to signaling from a point outside of the network.

At present, while communication control and the communications path are distinct from one another, both are dependent on the switch. The performance of both of these tasks by switches places limitations on a telecommunications network. One such limitation can be illustrated by one difficulty encountered in combining narrowband networks and broadband networks. Broadband networks are advantageous for data transmission because virtual permanent connections can be mapped through a network and bandwidth allocated on demand. Narrowband switches are advantageous for voice, in part, due to the many features which have been developed in conjunction with these switches. These features benefit both the user and the network through added efficiency and quality. Examples are "800" platforms, billing systems, and routing systems. However for broadband net-

works, the development of these features is incomplete and does not provide the functionality of current narrowband features. Unfortunately, narrowband switches do not have the capacity, speed, and multimedia capabilities of broadband switches. The resulting combination is separate overlay networks. Typically, narrowband traffic remains within the narrowband network, and broadband traffic remains within the broadband network.

Any intelligent interface between the two networks would require that signaling information be transmitted between narrowband switches and broadband switches. At present, the ability of these switches to signal each other is limited. These switch limitations create a major obstacle in any attempt to interface the two networks. It would be advantageous if narrowband and broadband networks could interwork through an intelligent interface to establish a communications path between points. At present, the interface between narrowband and broadband networks remains a rigid access pipe between overlay systems.

The reliance on switches to both perform communication control and to form the a part of the communications path results in impediments to developing improved networks. Each time a new network element, such as a broadband switch, is introduced, a telecommunications network may be forced to delay integrating the network element into its network until standardization of signaling and interface protocols are developed for the switches. At present, there is a need for a portion of the communication control processing to be independent of the switches that form a part of the communications path.

SUMMARY

An embodiment of the present invention solves this need by providing a method, system, and apparatus for communication control processing that is located externally to the switches that make the connections. The method includes receiving a first signal into a processor which is located externally to the switches in a network comprised of network elements. The processor selects a network characteristic in response to the first signal. The processor then generates a second signal reflecting the network characteristic and transmits the second signal to at least one network element. This transmission occurs before that network element has applied the first signal. Examples of network characteristics are network elements and connections, but there are others. Examples of signaling are Signaling System #7 or broadband signaling. The processor may also employ information received from the network elements or operational control when making selections. In one embodiment, the method includes receiving the first signal into a network from a point and routing the first signal to the processor.

The present invention also includes a telecommunications processing system which comprises an interface that is external to the switches and is operational to receive and transmit signaling. The processing system also includes a translator that is coupled to the interface and is operational to identify particular information in the received signaling and to generate new signaling based on new information. The processor also includes a processor that is coupled to the translator and is operational to process the identified information from the translator in order to select at least one network characteristic. The processor provides new information to the translator reflecting the selection. The identified information is used in the processor before it is used in the particular network elements that receive the new signaling.

The present invention also includes a telecommunications network comprised of a plurality of network elements wherein at least one network element is a switch, and a plurality of connections between the network elements. The network also includes a processor located externally to the switches which is operable to receive a first signal, to select at least one network characteristic in response to the first signal, and to generate a second signal reflecting the selection. The network also includes a plurality of links between the processor and the network elements which are operable to transmit the second signal to at least one network element before that network element has applied the first signal.

The present invention also includes a telecommunications signaling system for use in conjunction with a plurality of telecommunication switches. This system comprises a plurality of signaling points and a signaling processor. The signaling processor is linked to the signaling points and resides externally to the switches. The signaling processor is operational to process signaling and to generate new signaling information based on the processing. The new signaling is transmitted over the links to multiple signaling points. In one embodiment, the new signaling information is comprised of different signaling messages and the different signaling messages are transmitted to different signaling points.

In another embodiment, a plurality of the signaling points each reside in a different switch and are directly coupled to a processor in the switch that directs a switching matrix in the switch in response to signaling processed by the signaling point. The signaling processor is operational to direct the switching matrixes of multiple switches by signaling multiple signaling points. The signaling processor is also operational to signal multiple points in response to signaling from a single source, and to signal a point in response to signaling from multiple sources.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features, aspects, and advantages of the present invention will become better understood with regard to the following description, claims, and drawings where:

FIG. **1** is a block diagram of a version of the invention.

FIG. **2** is a block diagram of a version of the invention.

FIG. **3** is a block diagram of a version of the invention.

FIG. **4** is a logic diagram of a version of the invention.

FIG. **5** is a flow diagram of a version of the invention.

FIG. **6** is a flow diagram of a version of the invention.

FIG. **7** is a flow diagram of a version of the invention.

FIG. **8** is a flow diagram of a version of the invention.

DESCRIPTION

Telecommunications systems establish communications paths between points which allow the points to transfer information, such as voice and data, over the communication paths. Typically, telecommunications systems are comprised of network elements and connections. A network element is a telecommunications device such as a switch, server, service control point, service data point, enhanced platform, intelligent peripheral, service node, adjunct processor, network element of a different network, enhanced system or other network related device, server, center or system.

A connection is the media between two network elements that allows the transfer of information. A few examples of connections are: digital T1 lines, OC-3 optical fibers, packet connections, dedicated access lines, microwave transmission, and cellular radio. As those skilled in the art are aware,

connections can be described in a range from general to specific. All of the media between two switches is a general description and might correspond to a virtual path in an ATM system or a trunk groups in a T1 system. An individual circuit between two elements is more specific and might correspond to a virtual channel in an ATM system or a DS0 circuit in a T1 system. Connections can also be described as being logical or physical. Physical connections are electrical-mechanical media. Logical connections are paths which follow physical connections, but are differentiated from one another based on format and protocol. The term "connection" includes this entire range and the meaning varies according to the context in which the term is used. The present invention could make selections encompassing the entire range of connections.

A communications path is the combination of connections and network elements that physically transfers the information between points. A communication path may be point to point, point to multi-point, or multi-point to multi-point. These points, in turn, define the ends of the communications path. Thus, a connection may also be made between a network element and a point outside the network.

Signaling is the transfer of information among points and network elements and is used to establish communications paths. An example is Signaling System # 7 (SS7). Signaling is typically transmitted over links, such as 56 kilobit lines. On the block diagrams, signaling is represented by dashed lines and connections are represented by solid lines.

In FIG. **1**, Telecommunications System **110** comprises a communication control processor (CCP) **120** and first, second, third, fourth, fifth and sixth network elements, **131**, **132**, **133**, **134**, **135** and **136** respectively. First and second network elements, **131** and **132** respectively, are connected by first connection **141**. First and third network elements, **131** and **133** are connected by both second and third connections, **142** and **143** respectively. First and fifth network elements, **131** and **135** respectively, are connected by fourth connection **144**. Second and fourth network elements, **132** and **134** are connected by fifth connection **145**. The third network element **133** is connected to fourth and sixth network elements, **134** and **136** by sixth and seventh connections, **146** and **147** respectively. Fourth and fifth network elements, **134** and **135** are connected by connection **148**. A first point **170**, which is located outside of the system **110**, is connected to first element **131** by first point connection **171**, and a second point **172** which is also located outside the system **110** is connected to fourth element **134** by second point connection **173**. First and second points, **170** and **172** respectively and first, second, third, fourth, fifth and sixth elements **131**, **132**, **133**, **134**, **135**, and **136** respectively each are linked to CCP **120** by first, second, third, fourth, fifth, sixth, seventh, and eighth links, **191**, **192**, **193**, **194**, **195**, **196**, **197** and **198** respectively.

As those skilled in the art are aware, a system is typically comprised of many more network elements, links, connections and points, but the number is restricted for clarity. Points outside of the network can take many forms, such as customer premises equipment (CPE), telephones, computers, or switches of a separate network system. In addition the system **110**, may take many forms such as international gateways, satellite networks, wireless networks, local exchange carriers (LECs), inter-exchange carriers (IXCs), transit networks, national networks, personal communicator systems (PCS), virtual private networks, or connection oriented networks such as local area networks (LANs), metropolitan area networks (MANs), wide area networks (WANs) to name some examples.

In operation Telecommunications System **110** is able to accept information from first point **170** and second point **172** and transmit the information over the various network elements and connections which form the communications path. System **110** is also capable of exchanging signaling with first point **170** and second point **172** over the first link **191** and second link **192**.

On a standard call that establishes a communications path from first point **170** to second point **172**, first point **170** will signal Telecommunications System **110** that it requests the communications path. This signaling is directed to CCP **120** over first link **191**. CCP **120** processes the signaling and selects at least one network characteristic in response to the signaling. Network characteristics might be network elements, connections, network codes, applications, or control instructions to name a few examples. The selected network characteristic typically comprises one of a plurality of network elements and/or connections. The CCP **120** generates signaling which is preferably new signaling reflecting the selection. CCP **120** then transmits the signal to at least one of a plurality of network elements before that network element has applied the signal.

In one embodiment, CCP **120** selects the network elements and the connections that comprise the communications path. However, first point **170** will typically seize first point connection **171** contemporaneously with signaling. This initial connection could also be selected by CCP **120** from the available possibilities after the signaling by first point **170**. Assuming first point **170** has seized first point connection **171** to first element **131**, CCP **120** selects one, a plurality, or all of the remaining network elements and connections to further establish a communications path to second point **172**.

CCP **120** determines which element should be connected to first element **131**. CCP **120** could select either second element **132** or third element **133**. If third element **133** is selected, CCP **120** may also select the connection to third element **133** from among second and third connections, **142** and **143** respectively. If third connection **143** is selected, CCP **120** will signal first element **131** over third link **193** to further the communications path to third element **133** over third connection **143**.

CCP **120** may then make further selections to complete the communications path. As the possibilities have been limited for clarity, CCP **120** would make the selections and signal the elements as follows. CCP **120** would signal third element **133** over fifth link **195** to further the communications path to fourth element **134** over sixth connection **146**. CCP **120** would signal fourth element **134** over sixth link **196** to further the communications path to second point **172** over second point connection **173**. CCP **120** would also signal second point **172** over second link **192** of the communications path available through second point connection **173**. In this way, the communications path requested by first point **170** is selected by CCP **120** and signaled to the elements. Throughout this process, CCP **120** may receive status messages and signaling from the elements to support its processing. This status messaging may be transmitted and received over links, connections, or other communication means.

In another embodiment, CCP **120** may select only the network elements and not the connections. The elements would select the connections to use based on the network element selected by CCP **120**. For this embodiment, the main difference from the above example is that CCP **120** would instruct first element **131** to further the communications path to third element **133**, but first element **131** would

select the actual connection used from among second and third connections, **142** and **143**, respectively. First element **131** may signal CCP **120** over third link **193** of its selection so that CCP **120** may signal third element **133** of the connection over fifth link **195**. In this embodiment, CCP **120** would specify the network elements to the elements, which in turn, would select the connections between these network elements.

There are situations in which the selection of a network element and the selection of a connection signify the same thing. On FIG. **1** for example, instructing first element **131** to use first connection **141** is synonymous with an instruction to connect to second element **132**. This is because the connection inevitably connects to the element. The selection of a connection may effectively select a network element, and the selection of a network element may effectively select a connection (or a group of specific connections) to that network element.

One skilled in the art will recognize that the selection process can be distributed among the CCP and the elements. The CCP might select all the network elements, a portion of the network elements, or none of the network elements leaving the switches to select the remainder. The CCP might select all of the connections, a portion of the connections, or none of the connections, again leaving the elements to select the remainder. The CCP may select combinations of the above options, but the CCP will always select at least one network characteristic.

In another embodiment, first point **170** may want to access a other network elements such as servers, platforms or operator centers. For example, such elements could be located at either fifth or sixth network elements **135**, and **136** respectively. CCP **120** will receive signaling from first point **170** over first link **191** indicating this request, and first point **170** will typically seize first point connection **171** to first element **131**. Again CCP **120** will select network elements. If sixth element **136** is selected CCP **120** could select a communications path from first element **131** through either second element **132** to fourth element **134** and then to third element **133**, or through a direct connection from first element **131** to third element **133**. If CCP **120** selects the latter, it would signal first element **131** to further the communications path to third element **133**, and it would signal third element **133** to further the communications path to sixth element **136**. As discussed in the above embodiments, CCP **120** may also select the connections, or the elements may be left with that task.

As is known in the art, in-band signaling is typically used in many user to network connections, such as the local loop. This is because only one connection or link is typically provided to the user premises and thus, the signaling must be placed on the actual communications path. The initial network switch typically removes the signaling from the communications path and transfers it to an out-of-band signaling system. The current invention is fully operational in this context. Although the switch may receive the signaling initially, it will only route the signaling to the CCP for processing. Even if in-band signaling is used within the network, the switches could remove signaling from the communications path and route it to the CCP for processing in accord with the present invention.

Thus, preferably the CCP processes signaling before it is applied or processed by the switch such as to select connections or generate queries. Preferably, no or minimal changes are made to the signaling prior to the signaling being received by the CCP so that the CCP receives the signaling in the same format as a switch would receive the signaling. The CCP may also process the signaling in that format. The switches make their selections based on the CCP selections, thus the switch selections clearly occur after the CCP has processed the signaling. As such, the switch may route signaling to the CCP, but the switch does not apply the signaling. Some examples of a switch applying the signaling would be selecting network elements or generating queries for remote devices.

In one of the above embodiments, the switches did not select the network elements and connections, initiate the signaling, or otherwise control the communication. The switches only followed the instructions of the CCP and actually made the connections that furthered the communications path. In one embodiment, the switches were allowed to select the actual connections used, but even these selections were based on CCP selections.

As illustrated above, the CCP allows a telecommunications network to separate communication control from the communications path. In prior systems, the switches would select the network elements and the connections, as well as, actually providing a part of the actual connection. As a result, prior systems are restricted to the communication control capabilities provided by the switches. Prior systems have used remote devices, such as an SCP, to support switch control, but the remote device only answered queries in response to the switches processing of the signal. These remote devices do not process the signaling before the switch had already applied the signaling. By using the CCP, telecommunications systems can control communications independently of the capability of the switches to accomplish both tasks.

FIG. **2** shows a block diagram of another embodiment of the present invention. CCP **250** and network **210** are shown. CCP **250** is communications control processor CCP **250** could be integrated into network **210**, but need not be and is shown separately for clarity. Network **210** could be any type of telecommunications network that operates using network elements, signaling, and connections. Examples would be LECs, IXCs, LANs, MANs, WANs, and Cellular Networks, but there are others. Additionally, network **210** could be narrowband, broadband, packet-based, or a hybrid. Network **210** is capable of providing communications paths between points both inside and outside of network **210**. CCP **250** and network **210** are linked by link **214** and are able to signal each other in order to establish these paths.

Additionally, user **220** and user **230** are shown and are also capable of signaling. Examples of users **220** and **230** might be telephones, computers, or even switches in another telecommunications network. Users **220** and **230** are connected to network **210** by connections **222** and **232** respectively. Users **220** and **230** are linked to CCP **250** by links **224** and **234** respectively. Signaling may be transmitted over links **224** and **234**. If in-band signaling is employed on connections **222** and **232**, network **210** would separate at least a portion of the signaling out-of-band and transmit it to CCP **250** over link **214**.

Also shown are various network elements. As with CCP **250**, these elements could also be integrated into network **210**, but are shown separately for clarity. These network elements are: networks **260**, operator centers **262**, enhanced platforms **264**, video servers **266**, voice servers **268**, and adjunct processors **270**. This is not an exclusive list. Those skilled in the art will recognize these network elements and their functions, as well as the many other types of telecommunications devices, such as billing servers, that are applicable in this situation.

Each network element is connected to network **210** by connection **212**. Connection **212** represents several actual connections between the network elements (**260**-**270**) and different elements in network **210**. One bus-type connection is shown for purposes of clarity, but those skilled in the art are familiar with many actual types of connections to use. Additionally link **256** is shown from CCP **250** to the network elements (**260**-**270**). Link **256** is similarly represented as a bus-type link for clarity, and multiple links are actually used, although some network elements may not even require links. Link **214** has been simplified for clarity in the same fashion.

In one embodiment, user **220** may desire to establish a communications path to user **230**. CCP **250** would make the appropriate selections and signal the network elements in network **210** as discussed with regard to the embodiments of FIG. **1**. As a result, a communications path would be established from user **220** to user **230** through network **210** and connections **222** and **232**.

In another embodiment, user **220** may desire to access one of the various network elements (**260**-**270**). User **220** will typically seize connection **222** to network **210** and generate signaling. Both in-band signaling on connection **222** and out-of-band signaling on link **224** would be directed to CCP **250**. By processing the signaling, CCP **250** can select any of the network elements (**260**-**270**) and control the communications through network **210** and connection **212** to the network elements (**260**-**270**).

For example, should user **220** desire to connect to a video server and another network, user **220** would signal the request. The signaling would be directed to CCP **250** over link **224**, or over connection **222** and link **214** as discussed above. CCP **250** would process the signaling and make the appropriate selections. CCP **250** would signal network **210** and video servers **266** of its selections. As a result, a communications path would be set-up from user **220** to video servers **266**.

Additionally, CCP **250** would control communications to the other network which is represented by networks **260**. Networks **260** could be any other form of telecommunications network—either public or private. CCP **250** would make the appropriate selections to further the communications path over connection **212** and network **210** to networks **260**. Upon signaling from CCP **250**, the connections comprising the communications path would be made. Networks **260** would also be signalled by CCP **250** over link **256**. As such a communication path is set up from user **230** to video servers **266** and on to networks **260**.

There may also be several devices represented by particular network element shown on FIG. **2**. CCP **250** could also select the particular device to access. For example, take the situation in which voice servers **268** represents 20 individual voice server devices split among three different locations. On each call, CCP **250** could select the actual voice server device which should be used on that call and control the communications through network **210** and connection **212** to the selected device. Alternatively, CCP **250** may only be required to select group of devices, for instance at a particular location, instead of the actual device.

As is known, large telecommunication networks are comprised of numerous network elements, connections, and links. The present invention is suitable for use in this context. FIG. **3** shows a version of the present invention in the context of a large network. Typically, this network would be comprised of several broadband switches, narrowband switches, muxes, signal transfer points (STPs), Service Control Points (SCPs), operator centers, video servers, voice servers, adjunct processors, enhanced services platforms, connections, and links. For purposes of clarity, only a few of these possibilities are shown on FIG. **3**. For the same reason, connections and links are not numbered.

FIG. **3** shows Telecommunications Network **310** which is comprised of STP **340**, STP **345**, CCP **350**, SCP **355**, broadband switches **360**, **362**, **364**, and **366**, interworking units **361** and **365**, narrowband switches **370** and **375**, and muxes **380**, **382**, **384**, and **386**. Aside from CCP **350**, these elements of a large network are familiar to one skilled in the art and examples of the of these network elements are as follows: STP—DSC Communications Megahub; SCP—Tandem CLX; broadband switch—Fore Systems ASX-100; narrowband switch—Northern Telecom DMS-250; and mux—Digital Link PremisWay with CBR module.

In at least one embodiment, the broadband switches are equipped with signaling interworking units. These units translate SS7 messages into B-ISDN messages. In that event, the CCP could transmit SS7 to the broadband switches which could convert the signals, properly. Interworking is discussed in ITU-TS Recommendation Q.2660, "B-ISDN, B-ISUP to N-ISUP Interworking."

When user information passes from a broadband network to a narrowband network, it typically must pass through a mux. Muxes can convert transmitted information back and forth between narrowband and broadband formats. In at least one embodiment, each broadband connection on one side of a mux corresponds to a narrowband connection on the other side of the mux. In this way, the CCP can track connections through the mux. If the communication path is on a given narrowband connection entering the mux, it will exit the mux on its corresponding broadband connection. This correspondence allows the CCP to identify connections on each side of the mux based on the entry connection. Muxes are typically placed at any interface between narrowband and broadband connections.

As long as the connections correspond through the mux, the CCP can track the communication path properly. Alternatively, the connections may not correspond. In that case, signaling links between the muxes and the CCP would be required for the devices to communicate and allow the CCP to track the communication path.

Additionally, Telecommunications Network **310** includes the connections and links which are not numbered. These connections and links are familiar to those skilled in the art. Some examples of possible connections are switched digital lines, satellite links, microwave links, cellular links, and dedicated digital lines, but there are others. The signaling links are typically data links, such as 56.kilobit lines. The signaling may employ SS7. Broadband, C6, C7, CCIS, Q.933, Q.931, T1.607, Q.2931, B-ISUP or other forms of signaling technology. The present invention is fully operational with the many variations which are well known in the art. Additionally, it is also known that a direct link between two devices can be used instead of an STP for signal routing.

Outside of Telecommunications Network **310** are first point **320**, second point **330**, LEC switch **325**, LEC switch **335**, LEC STP **328**, and LEC STP **338**. These devices are shown along with their links and connections. First point **320** is connected to LEC switch **325**. LEC switch **325** is linked to LEC STP **328** which mutes signaling from LEC switch **325**. LEC switch **325** is also connected to mux **380** of Telecommunications Network **310**. LEC STP **228** is linked to STP **340** of Telecommunications Network **310**.

STP **340** is linked to STP **345**. The other links are as follows. STPs **340** and **345** are linked to CCP **350**. CCP **350** is linked to interworking units **361** and **365** of broadband switches **360** and **364** respectively. CCP **350** is linked to

broadband switches **362** and **366**, and narrowband switch **375**. STP **345** is linked to narrowband switch **370** and SCP **355**. STP **345** is also linked to LEC STP **338** which is linked to LEC switch **335**.

Mux **380** is connected to broadband switch **360**. Broadband switch **360** is connected to broadband switches **362** and **364**. Broadband switch **362** is connected to mux **384** which is connected to narrowband switch **375**. Broadband switch **364** is connected to mux **382** which is connected to narrowband switch **370**. Broadband switches **362** and **364** are both connected to broadband switch **366**. Broadband switch **366** is connected to mux **386** which is connected to LEC switch **335**. LEC switch **335** is connected to second point **330**.

When a call is placed from first point **320** that requires the use of Telecommunications Network **310**, LEC switch **325** will typically seize a connection to Telecommunications Network **310** and generate a signal containing call information. At present, this signal is in SS7 format and the seized connection is a DS0 port. The signal is transmitted to LEC STP **328** which transfers it on to STP **340**. LEC switch **325** also extends the communication path over the seized connection. These LEC components and the process of establishing communication paths between a point, a LEC, and an IXC are familiar to those skilled in the art.

Telecommunications Network **310** accepts the communication path on the narrowband side of mux **380**. The present invention can also accept broadband calls that do not require a mux, but typically, calls from a LEC will be narrowband. Mux **380** converts the call to broadband and places it on the broadband connection that corresponds to the seized connection. The communication path extends to broadband switch **360** through mux **380**.

STP **340** transfers the signal from LEC STP **328** to STP **345** which, in turn, routes the signal to CCP **350**. Also, CCP **350** accepts status messages from the broadband and narrowband switches over standard communications lines, and may query SCP **355** for information. Any suitable database or processor could be used to support CCP **350** queries. CCP **350** uses this information and its own programmed instructions to make communication control selections. For calls that require narrowband switch treatment, CCP **350** will select the narrowband switch.

Preferably, CCP **350** can select any narrowband switch in Telecommunications Network **310**. For example, it may extend the communication path through the broadband network to a narrowband switch across the network for processing, or it may extend the communication path to a narrowband switch connected to the broadband switch that originally accepts the communication path. Additionally, no narrowband switch may be required at all. For clarity, all of the switches representing these possibilities are not shown on FIG. **3**.

CCP **350** will select at least one network characteristic in response to the signaling. Typically, this will be the network elements or connections that will make the communication path. As discussed with regard to the above embodiments, CCP **350** may select only the network elements and allow the switches to select the connections, or the selections can be distributed among the two. For example, CCP **350** may only select some of the network elements and connections and allow the switches to select some of the network elements and connections. CCP **350** might only select the narrowband switches and allow the broadband switches to select the broadband switches that will make the communication path. CCP **350** can also select other network characteristics, such as applications and control instructions.

In one embodiment, CCP **350** will select the narrowband switches to process particular calls and the DS0 ports on those switches which will accept these calls. The broadband switches will select the broadband switches and the broadband connections to the DS0 port. Restricted to the possibilities depicted on FIG. **3**, CCP **350** may select either narrowband switch **370** or narrowband switch **375** to process the call. Assuming CCP **350** selects narrowband switch **370**, it would also select a DS0 port on narrowband switch **370** to accept the connection. CCP **350** would then signal broadband switch **360** through interworking unit **361** to further the communications path to the selected DS0 port on narrowband switch **370**.

Of the possible routes, broadband switch **360** would be left to select the other broadband switches and connections to use. Assuming the route directly to broadband switch **364** is selected, broadband switch **360** would further the communications path to that switch. Broadband switch **360** would also signal broadband switch **364** of the communication path. Broadband switch **364** would farther the communication path to through mux **382** to access the specified DS0 port on narrowband switch **370**. This is accomplished by corresponding the connections through the mux as discussed above. CCP **350** will signal narrowband switch **370** of the incoming communication path. This signal is routed by STP **345**. Narrowband switch **370** will process the call on the specified DS0 port. Typically, this would include billing and routing the call. Narrowband switch **370** may also query SCP **355** to aid in application of services to the call. For example, narrowband switch **370** may retrieve an "800" translation from SCP **355**. As a result of the processing, narrowband switch **370** will switch the call and generate a new signal which may include routing information. The signal is sent to CCP **350** through STP **345**. The communication path is furthered on a new connection back to broadband switch **364** through mux **382**. CCP **350** may use the information in the signal, SCP information, network element information, operational instructions, and/or its own routing logic to make new selections for the call. The network element information and operational instructions could be signalled to CCP **350** or delivered over standard data lines.

In one embodiment, the selection of a network characteristic will include the selection of a network code. Network codes are the logical addresses of network elements. One such code is a destination code that facilitates egress from Telecommunications System **310**. The destination code typically represents a network element that is connected to a LEC switch. Once a destination is selected, CCP **350** will signal broadband switch **364** of its selections and the communication path will be furthered through the broadband network accordingly. In the current example this could be through broadband switch **366** and mux **386**. The communication path would be furthered to the specified port on LEC switch **335**. Typically, this involves the seizure of a connection on the LEC switch by the IXC.

In one embodiment, whenever broadband switch **366** extends a communication path to mux **386**, it is programmed to signal CCP **350** of the broadband connection it has selected. This allows CCP **350** to track the specific DS0 port on the LEC switch that has been seized. CCP **350** would signal LEC switch **335** through STP **345** and LEC STP **338** of the incoming call on the seized DS0 connection. As a result, LEC switch **335** would further the communication path to second point **330**.

It can be seen from the above disclosure that the present invention allows a telecommunications network to employ a

broadband network to make call connections. By using muxes to convert calls and a CCP to analyze signaling, this broadband network remains transparent to the networks of other companies. An example of such a transparent interface is between an interexchange carrier (IXC) network and a local exchange carrier (LEC) network. Similarly the network will be transparent if deployed in only a portion of a single company's network infrastructure.

In the above embodiment, the LEC seizes an IXC DS0 port and signals to an IXC STP. The mux and the CCP convert the call and analyze the signal appropriately. No changes in other existing carrier systems, such as LEC systems, are required.

Additionally the narrowband switch receives the call and signal in its own format and switches the call. Although the switch may "think" the call is routed over a trunk to another narrowband switch, the call actually goes right back to the mux and broadband switch that sent the call. The narrowband switch is used to apply features to the call, i.e. billing, routing, etc. The broadband network is used to make the substantial portion of the call connection. The CCP may use narrowband switch call processing information to make selections.

The CCP performs many functions. In one embodiment, it accepts signaling from a first point or LEC and provides appropriate signals in accord with the communication control selections it has made. These selections are network characteristics. The CCP may select network elements such as switches, servers, or network codes. The CCP may select connections, such as DS0 circuits and ports. The CCP may select particular telecommunications applications to be applied to the communications path. The CCP may select particular control instructions for particular devices. The CCP may also receive information from entities such as SCPs, operational control, or switches to aid in its selections.

The CCP is a processing system, and as such, those skilled in the art are aware that such systems can be housed in a single device or distributed among several devices. Additionally, multiple devices with overlapping capabilities might be desired for purposes of redundancy. The present invention encompasses these variations. One such operational system would be multiple pairs of CCPs located regionally within a telecommunications system. Each machine would be equally capable of communication control. One example of a CCP device would be a Tandem CLX machine configured in accord with this disclosure of the present invention.

A signaling point handles the signaling for a switch. Switches which are used to route calls typically have a signaling point which is directly coupled to a processor in the switch. This processor controls a switching matrix in the switch in response to the signaling processed by the signaling point. Thus, there is typically a one to one correspondence of a signaling point for each switch and matrix.

The CCP is not directly coupled to one switch, one switch processor (CPU), or one switching matrix. In contrast, the CCP has the capability of directing a plurality of switches. Thus, the CCP can direct multiple switch matrixes by signaling multiple signaling points.

It is possible to house the CCP within other telecommunication devices, even switches. Although the CCP can be primarily distinguished from a switch CPU based on physical location, this does not have to be the case. A switch CPU receives information from a signaling point and controls the matrix of a single switch. Some switches distribute the matrix among different physical locations, but the CPU

controls each matrix based on information received from a single signaling point. This information is not signaling.

In contrast, the CCP receives signaling and has the ability to signal other network elements. It can communicate with multiple signaling points. These signaling points provide information to the switch CPUs which control the switch matrixes. By signaling multiple signaling points, the CCP is able to direct the matrixes of multiple switches based on the signaling and other information the CCP obtains. A CCP is not associated with a single switch matrix. A CCP does not require communication path connections in order to operate.

The main capabilities of one version of a CCP are shown on FIG. **4**. CCP **450** comprises interface **460**, translator **470** operably connected to interface **460**, processor **480** operably connected to translator **470**, and memory **490** operably connected to processor **480**.

CCP **450** functions to physically connect incoming links from other devices such as STPs, switches, SCPs, and operational control systems. Interface **460** is functional to accept the signals off of these links and transfer the signals to translator **470**. Interface **460** is also be able to transfer signaling from translator **470** to the links for transmission.

Translator **470** accepts the signaling from interface **460** and identifies the information in the signaling. Often, this will be done by identifying a known field within a given signaling message. For example, translator **470** might identify the Origination Point Code (OPC), Destination Point Code (DPC), and Circuit Identification Code (CIC) in an SS7 message. Additionally, translator **470** must be able to formulate outgoing signaling and transmit it to interface **460** for transmission. For example, translator **470** might replace the OPC, DPC, and CIC in a given SS7 message and transfer the modified SS7 message to interface **460** for transmission. Translator **510** must be equipped to manage the signaling formats it will encounter. Examples are SS7 and C7.

Processor **480** accepts the signaling information from translator **470** and makes the selections that accomplish communication control. This includes the selection of the network elements and/or connections that make the communications path. Typically, selections are made through table look-ups and SCP queries. Tables are entered and queries are generated based in part on the information identified by translator **470**. The table look-ups and SCP information retrieval yield new signaling information. The new information is transferred to translator **470** for formulation into appropriate signals for transmission. Algorithm solution could also be used to make selections. Processor **480** also handles, various status messages and alarms from the switches and other network elements. Operational control can also be accepted. This information can be used to modify the look-up tables or selection algorithms. Memory **490** is used by processor **480** to store programming, information, and tables.

FIG. **5** shows a flow diagram for the CCP for a version of the present invention. The sequence begins with the CCP receiving different types of information. Box **500** depicts the CCP accepting a signal from a first point. This signal could be in any format, such as SS7 or broadband signaling. The signal may have passed through STPs from a LEC over a signaling link, or it may also be a signal directly provided by an individual user of a network. The signal contains information about the requested communication path. An example of such information is the message type which indicates the purpose of the message. Another example of such information is set-up information such as transit network service value, bearer capability, nature of address, calling party category, address presentation restriction sta-

tus, carrier selection value, charge number, and originating line information, and service code value. Other information might be a network indicator or a service indicator. Those skilled in the art are familiar with these types of information.

Other types of information might also be accessed by the CCP. The network elements, such as switches, may provide the CCP with information as shown in box **505**. This information allows the CCP to select network elements and connections based on network conditions. Examples of possible types of such information could be management messages, loading, error conditions, alarms, or idle circuits. The CCP might also provide the network elements with information.

Box **510** shows that operational control might be provided. Operational control allows system personnel to program the CCP. An example of such control might be to implement a management decision to retire a particular network element. Operational control would allow the removal that element from the selection process.

The CCP processes the information is has received in box **515**. Processing also entails the use of programmed instructions in the CCP, and might even include the use of information retrieved from a remote database, such as an SCP. The selections are then made as shown in box **520**. These selections specify network characteristics, such as network elements and/or connections. As stated above, The CCP may only select a portion of the network characteristics and allow the points or the switches to select the remainder. It should be pointed out, that the information used in processing is not limited to that which is listed, and those skilled in the art will recognize other useful information which may be sent to the CCP.

Once network characteristics are selected, the CCP will signal the points and the applicable network elements of the selections. In box **525**, signals are formulated instructing the network elements of the network characteristics selected. The signals are transmitted to the appropriate network elements in box **535** which will typically result in a communication path through the network elements and connections. Other activity, such as applications and control procedures might be implemented as well. Additionally, in boxes **530** and **540**, signals are formulated and sent to the points. Typically the new signals generated by the CCP are sent to network elements or multiple signaling points. These new signals could be the same, however different signaling is typically sent to the different network elements which may used as part of a communication path.

FIG. **5** represents the sequence that the CCP performs in one embodiment to control communications and establish a communication path from a first point to a second point through network elements and connections. FIGS. **6** and **7** represent a similar sequence, and they are in the context of an Interexchange Carrier (IXC) similar to that depicted in FIG. **3**. The IXC accepts DS0 connections and SS7 signaling from a LEC and employs a broadband system to make the substantial portion of the communication path.

FIG. **6** depicts the flow of the CCP in a version of the present invention when a communication path is established from the LEC to a narrowband switch in the IXC. Box **600** shows that an SS7 message is accepted from the LEC which contains a Message Transfer Part (MTP) and an Integrated Service User Part (ISUP). As those skilled in the art are aware, the MTP contains the Originating Point Code (OPC) and the Destination Point Code (DPC). These point codes define specific signaling points in the network and are typically associated with a switch. As such, the OPC and DPC define a portion of the desired communication path.

When the communication path is extended into the IXC network, the OPC designates the LEC switch that connected to the IXC (#**325** on FIG. **3**). Previously, the DPC has designated the narrowband switch that the LEC would connect to for calls into the IXC. In this embodiment of the present invention, the DPC may designate a particular narrowband switch from the LEC's perspective, but the CCP actually selects the actual narrowband switch used. A mux or a broadband switch accepts the connection from the LEC, not a narrowband switch.

The ISUP contains the Circuit Identification Code (CIC) which designates the DS0 port that the LEC has seized. Previously, this DS0 Port was on a narrowband switch, but in this embodiment of the present invention, the DS0 port is actually on a mux.

Box **605** shows that the CCP may receive status information from the narrowband switches. These messages include Operational Measurements (OM) and CPU Occupancy information. OM includes trunk usage status of the switches which tells the CCP which DS0 ports are available on the narrowband switches. CPU Occupancy tells the CCP of the specific switching load of each narrowband switch. Box **610** shows that the CCP may also accept status information from the broadband switches indicating which connections are idle. This information allows the CCP to specify and balance routing through the broadband switches if desired. As discussed in relation to some of the other embodiments, the broadband switches may be left with that selection.

The CCP processes the information it has received in box **615**. Those skilled in the art are aware of other information which would be useful in this context. As a result of the processing, a narrowband switch and a DS0 port on that switch are typically selected as shown in box **620**. The selected narrowband switch may be close to the LEC or across the broadband network. The CCP determines which narrowband switch will process the call. This makes the narrowband switches virtually interchangeable.

Box **625** shows that a signal indicating these selections is generated and sent to the appropriate broadband switches in box **635**. As discussed, the broadband switches may employ interworking units to handle signaling. Typically, the broadband switches will use internal tables to select broadband connections based on information in the signal from the CCP. Such information might identify the existing extent of the communication path and specify the narrowband switch and the DS0 port on that switch to which the communication path should be extended. The tables would be entered with this information and yield a particular broadband connection to use. Broadband switches further along the communications path could also receive similar signals from the CCP and use similar tables. Alternatively, the broadband switches further along the communications path might only need to enter an internal table using the incoming broadband connection and yield a new broadband connection on which to extend the communications path.

Those skilled in the art are familiar with broadband systems which can accomplish this. Broadband signaling is discussed in the following ITU-TS Recommendations: Q.2762 "B-ISDN, B-ISDN User Part—General Functions of Messages"; Q.2763 "B-ISDN, B-ISDN User Part—Formats and Codes"; Q.2764 "B-ISDN, B-ISDN User Part—Basic Call Procedures"; Q.2730 "B-ISDN, B-ISDN User Part—Supplementary Services"; Q.2750 "B-ISDN, B-ISDN User Part to DSS2 Interworking Procedures;" and Q.2610 "Usage of Cause and Location in B-ISDN User Part and DSS2."

In at least one embodiment, the broadband switches are equipped with signaling interworking units. These units translate SS7 messages into B-ISDN messages. In that event, the CCP could transmit SS7 to the broadband switches which could convert the signals properly. Interworking is discussed in ITU-TS Recommendation Q.2660, “B-ISDN, B-ISUP to N-ISUP Interworking.”

In one embodiment, the broadband switches may select the actual virtual connection that corresponds through a mux to a DS0 port. This DS0 port could be on a narrowband switch or a on a point, such as a LEC switch. In this case, the CCP would not need to select a DS0 port since the broadband switch was in effect doing so. The internal tables of the broadband switches would be programmed to trigger when the particular broadband switch was connecting to particular broadband connections. These connections might be to a DS0 port on a narrowband switch or any specified point. Upon the trigger, the broadband switch would signal the CCP of the broadband connection it has used. The CCP would incorporate this information into the signal it sends to the narrowband switch or specified point. It is preferred that the CCP select the DS0 port on the selected narrowband switches, and that the broadband switches be allowed to select the broadband connection out of the network (through a mux) and signal the CCP of its selection.

The SS7 message from the LEC informed the CCP which DS0 port had been seized (the CIC), on which IXC device (DPC), and by which LEC switch (the OPC). By tracking the DS0 Port through the mux (#**380** on FIG. **3**), the .CCP knows which connection the communication path will use to get to the broadband switch (#**360** on FIG. **3**). The CCP provides the broadband network with the proper signaling to extend the communication path from this switch to the selected narrowband switch as shown in box **635**.

Box **630** shows that the CCP formulates an SS7 message based on the selections relating to the narrowband switch. SS7 message formulation methods, such as drop and insert, are known in the art. A new DPC is inserted that will designate the narrowband switch selected by the CCP. A new CIC is inserted that will designate the DS0 port on that switch as selected by the CCP. The SS7 message is sent to the narrowband switch in box **640**.

As such, the communication path is extended from the LEC through the broadband network to the narrowband switch, and the narrowband switch is notified of the incoming communication path. Another portion of the SS7 message contains call information including ANI and DNIS. This information was supplied by the LEC and is in the SS7 message sent to the narrowband switch.

The narrowband switch uses this information along with its own programming to switch the call. This switching may include various switching programs and remote databases. The narrowband switch will select a new DPC based on this processing. It will switch the call to a new DS0 port. Previously, this port was connected to a trunk connected to the next narrowband switch in the call routing scenario. However, in the present invention, the DS0 port is connected through a mux to broadband switch. The narrowband switch will place the new DPC in an SS7 message. Along with the new DPC, a new CIC identifying the, new DS0 circuit, and a new OPC designating the narrowband switch itself is placed in the SS7 message and sent to the CCP.

FIG. **7** shows the flow of the CCP when extending a communication path from the selected narrowband switch to a point outside of the IXC in one embodiment of the present invention. The SS7 message generated by the narrowband switch after processing the call is received by the CCP in box **700**. In it, the CIC designates the DS0 port the communications path extends from on the narrowband switch. Because this port is connected to a mux with corresponding connections, the CCP can determine which connection the communication path uses to extend back to the broadband switch.

The CCP may also receive status information from the broadband switches as shown in box **705**. This information allows the CCP to select broadband connections if desired. As discussed, the broadband switches may make these selections. Typically, the broadband switches will use internal tables to select broadband connections based on information in the signal from the CCP. Such information might specify, destination code. The destination code might correspond to a terminating switch or a LEC switch to which the communication path should be extended.

As shown in box **710**, the CCP applies processing and selects the appropriate destination for the broadband network to extend the communication path to as shown in box **715**. The CCP may use the new DPC provided by the narrowband switch to identify the destination for the broadband communication path.

In box **720**, signals are generated reflecting this selection and sent to the appropriate broadband switches in box **725**. As discussed, the broadband switch may trigger and signal the CCP when it uses particular connections. This would occur for a connection through a mux to a LEC switch. This signal is accepted by the CCP in box **730** and is used to identify the DS0 port. An SS7 message is formulated in box **735** and in it the CIC will identify this DS0 connection on the LEC switch (#**335** on FIG. **3**). Alternatively, this DS0 port may have been selected by the CCP and signalled to the broadband switch. The LEC is signalled in box **740**.

From FIGS. **6** and **7**, a sequence is shown that demonstrates the procedures that the CCP can follow to accept signaling from the LEC and make selections that control communications through the IXC network. The CCP must produce signals to implement its selections and transmit them to the applicable network elements. The CCP is able to use the routing, billing, and service features of a narrowband switch, but is still is able to employ a broadband network to make a substantial part of the communications path.

FIG. **8** is a flow diagram of CCP signal processing in one embodiment of the invention. Box **800** shows that an SS7 signal has been accepted by the CCP. Box **805** shows that the CCP determines the message type. If the message is not a call message, it is routed or used to update the CCP memory if appropriate as shown in box **810**. Non-call messages are familiar to those skilled in the art with examples being filler or management messages. If the SS7 message is a call message, it is examined to determine if it is an initial address message (IAM) in box **815**. Call messages and IAMs are familiar to those skilled in the art. If it is an IAM, the information provided by automatic number identification (ANI) is used to validate the call in box **820**. ANI validation is accomplished with a table look-up and is well known. If invalid, the communication path is terminated as shown in box **825**.

Once an IAM with a valid ANI is determined, a table is entered, which yields an OPC—DPC—CIC combination as shown in box **830**. One skilled in the art will recognize that such a table can take many forms. One example is to set up a table with every combination of OPC—DPC—CIC on one side. The table is entered using the OPC—DPC—CIC of the incoming IAM message. After entry through these fields is accomplished, the table yields a new OPC—DPC —CIC which can be formulated into the SS7 message and sent to

the switching network as shown in box **835**. The switching network is capable of using this information to make connections.

Once the IAM signal has been processed, subsequent SS7 messaging can be processed by a separate CIC look-up table entered using the CIC as shown in box **840**. Subsequent messages, such as address complete, answer, release, and release complete can be processed by entering the CIC table using the CIC in these non-IAM signals. For signals directed to the first point, the table yields the original OPC which is used as the DPC. Additionally, subsequent messages from the first point enter the CIC table using their CIC, and the table yields the DPC previously selected by the CCP for the IAM processing. The CIC table is constantly updated to reflect current processing as shown in box **845**. In this way, the CCP is able to efficiently process non-IAMs because these signals only need to reflect the results of previous IAM selections.

There can be exceptions to the use of the CIC table for non-IAM call messages. One example would be if a new connection is allowed after release. In that case, the IAM procedures would be followed.

Those skilled in the art will recognize the numerous factors that can be used to design and load the tables. Different OPC—DPC—CIC combinations can be yielded by the tables based on many factors. Some of these factors are: called number, time of day, CPU occupancy, switch status, trunk status, automatic call distribution, operational control, error conditions, network alarms, user requests, and network element status.

For example, if a certain switch must be taken out of service, it is merely replaced in the table with suitable substitutes. The switch is then effectively taken out of service because it is no longer selected. If the CPU loading of a certain switch reaches a threshold, its presence in the tables can be diminished and distributed to other switches.

In another example, if it is busy hour in region A, the tables may yield network elements in region B to process the call. This can be accomplished by adding an area code or a dialed number entry, and time of day entry in the table. For calls placed from an OPC in region A to an area code or dialed number in region B, a narrowband switch in region B could be selected. As such, the DPC yielded by the table during this time frame should reflect a region B narrowband switch. Also, for calls placed from an OPC in region B to an area code or dialed number in region A, the tables should provide the DPC of a region B narrowband switch.

In a preferred embodiment, IAM messages would cause the CCP to query an SCP, data element, or database for support. The SCP would answer the query by using tables as discussed above. The answers would sent to the CCP and used to formulate signaling. Subsequent messages would be then handled by the CCP using the CIC table. An example of such support would be for the CCP to query the SCP in response to receiving an IAM message. The query may include the OPC, CIC, DPC, and the area code, or dialed number. The SCP could use this information to select network characteristics and avoid busy regions as described in the above busy region example. For example, the SCP would maintain tables for OPC—dialed area code—time of day combinations that would yield a new DPC and CIC. This assumes that busy hour in a region corresponds to time of day, but other factors and yields could also be involved.

In one embodiment, the dialed number or area code could he used to select the new DPC, and time stamps could be placed in the signaling. This might entail tables with OPC—dialed area code entries that yield a new DPC and CIC. In this case, narrowband switches may not even be needed since billing can be applied using the time stamps. The CCP could then route the call directly using only the broadband network. This is especially relevant for POTS calls in which only an area code entry would need to be added to the tables.

As discussed above, often a connection will consist of two separate connection procedures. One connection procedure will be from the origination to a selected network element. The other connection procedure will be from the selected network element to the destination. Also it has been disclosed that the CCP could actually be discreet machines located regionally. In these cases, the CCP device processing the first connection procedure could be located in the origination region, and the CCP device that processes the second connection procedure could be located in the region of the selected network element.

The present invention offers the advantage of separating at least a portion of the communication control from the communication path. By examining and translating signaling independently of the communication path, multiple switches and network elements can be connected in the optimum way. Communications paths are no longer limited to only the connections the switches can control. Networks do not have to wait for standardization among signaling and interface protocols.

The present invention allows for the selection of network characteristics, such as network elements and connections, before switches process or apply the signaling. The switches are not required to have a capability either to make selections or to signal each other. The switches only make connections as directed by the CCP which signals in each switches own signaling format. Various criteria can be used for the selections in the CCP, such as time of day, load balancing, or invalid ANI. As such, the present invention allows for a smooth transition from narrowband to broadband networks. It also allows for the selection of network elements, such as servers and enhanced services platforms.

The present invention represents a fundamental and powerful departure from previous telecommunications technology. By separating the communications path from communication control, the CCP can utilize different networks and network devices intelligently. Previously, telecommunications systems have been dependent on the switches to accomplish communication control. As such, telecommunications systems have had to wait for the switches to develop communication control before new technology could be implemented. Switches have always been required to physically make connections and provide control over which connections are required. Switch capabilities have not been able to keep up with all of the network possibilities available. The result is a limited system.

Switches have been given support in this dual task. SCPs, STPs, and adjunct processors provide support for communication control. However, these devices only support the switches communication control, and the switch remains essential to communication control. This dependence has created a bottleneck given the available network possibilities.

One advantage of the present invention is that it allows narrowband switches be used interchangeably in a narrowband/broadband hybrid network. Any narrowband switch may be taken out of service without re-routing traffic and changing routing logic in each switch. The CCP is simply programmed not to select the given narrowband switch for call processing. The CCP will route calls over the broadband

network to another narrowband switch. This flexibility also allows the telecommunications network to easily transfer narrowband switch loads.

An important advantage of this system is that both the advantages of broadband and narrowband systems are utilized. The transmission capabilities of a broadband network are coupled with the narrowband network's ability to apply features. For example, the CCP can use the broadband network to substantially make the call connection from origination to destination. The CCP diverts the traffic to the narrowband network for processing. The narrowband network can apply features, such as billing and routing. Once processed, the traffic is directed back to the broadband network for completion of the connection. The CCP can then use the routing information generated by the narrowband system to route the traffic through the broadband system to the destination. As a result, the telecommunications system does not have to develop a billing or "800" routing feature for its broadband network. This can be accomplished because the CCP allows both networks to work together intelligently.

Another advantage of the present invention is the elimination of a substantial percentage of the DS0 ports required on the existing narrowband switches. In the current, architectures, narrowband switches are interconnected to each other. A substantial percentage of the switch ports are taken up by these connections. By eliminating the need for the switches to connect to each other, these ports can be eliminated. Each narrowband switch is only connected to the broadband system. This architecture requires fewer ports per switch. By load balancing with the CCP, the number of ports required on busy switches can be reduced. The architecture in the present invention does require additional broadband ports, but these can be added at a significant cost saving versus narrowband ports.

Additionally, the narrowband switches no longer signal each other since all signaling is directed to the CCP. This concentration accounts for a reduction in required signaling link ports. This reduction possibly could result in the elimination of STPs.

As mentioned above, an advantage of the present invention is its ability to treat narrowband switches, or groups of narrowband switches, interchangeably. The CCP can pick any narrowband switch to process a particular call. This allows the network to pull narrowband switches out of service without taking extreme measures. In turn, this simplifies the introduction of new services into the network. A switch can be pulled out of service simply by instructing the CCP to stop selecting it. The switch can be re-programmed and put back into service. Then the next switch can then be updated in the same manner until all of the switches are implementing the new service. Switches can also be easily pulled to test developing applications.

This narrowband switch flexibility also allows the CCP to balance switch loads through the network during peak times, or during mass calling events. This eliminates the need to implement complex and expensive load balancing features in the narrowband network. Instead of programming the several switches to balance among themselves, one command to the CCP can achieve this.

Another advantage is the reduction in call set-up time. Most large networks require that a call pass through more than two narrowband switches arranged in a hierarchical fashion. One large network employs a flat architecture in which all narrowband switches are interconnected, but this still requires that the call pass through two narrowband switches. In the present invention, only one narrowband switch is required for each call. The use of broadband switches to set-up and complete the call represents significant time savings.

What is claimed:

1. A communication network comprising:

a processing system configured to process one of a Signaling System #7 (SS7) signaling message and a Q.931 signaling message for a call to select packet routing information for the call and to transfer a control message indicating packet routing information; and

a communication system configured to receive a user communication for the call and the control message, and in response, convert the user communication into a packet format including the packet routing information selected by the processing system and transfer the user communication in the packet format to a packet system that routes the user communication based on the packet routing information selected by the processing system.

2. The communication system of claim **1** wherein the packet routing information comprises an address.

3. The communication system of claim **1** wherein the packet routing information indicates a virtual connection.

4. The communication system of claim **1** wherein the packet routing information comprises a network code representing a network element to egress the call from the packet system.

5. The communication system of claim **1** wherein:

the processing system is configured to process another one of an SS7 signaling message and a Q.931 signaling message for the call to transfer another control message indicating call termination; and

the communication system is configured to receive the other control message and responsively terminate the call.

6. The communication system of claim **1** wherein the processing system is configured to access a Service Control Point (SCP) based on the signaling message to select the packet routing information.

7. The communication system of claim **1** wherein the processing system is configured to generate and transfer billing information for the call.

8. The communication system of claim **1** wherein the communication system is configured to receive the user communication for the call in a Time Division Multiplex (TDM) format.

9. The communication system of claim **1** wherein the communication system is configured to receive the user communication for the call in a DS0 format.

10. The communication system of claim **1** wherein the processing system is external to the communication system.

11. A method of operating a communication network, the method comprising:

in a processing system, processing one of a Signaling System #7 (SS7) signaling message and a Q.931 signaling message for a call to select packet routing information for the call and transferring a control message indicating packet routing information; and

in a communication system, receiving a user communication for the call and the control message, and in response, converting the user communication into a packet format including the packet routing information selected by the processing system and transferring the user communication in the packet format to a packet system that routes the user communication based on the packet routing information selected by the processing system.

12. The method of claim **11** wherein the packet routing information comprises an address.

13. The method of claim **11** wherein the packet routing information indicates a virtual connection.

14. The method of claim **11** wherein the packet routing information comprises a network code representing a network element to egress the call from the packet system.

15. The method of claim **11** further comprising:

in the processing system, processing another one of an SS7 signaling message and a Q.931 signaling message for the call and responsively transferring another control message indicating call termination; and

in the communication system, receiving the other control message and responsively terminating the call.

16. The method of claim **11** further comprising, in the processing system, accessing a Service Control Point (SCP) based on the signaling message to select the packet routing information.

17. The method of claim **11** further comprising, in the processing system, generating and transferring billing information for the call.

18. The method of claim **11** wherein receiving the user communication for the call comprises receiving the user communication in a Time Division Multiplex (TDM) format.

19. The method of claim **11** wherein receiving the user communication for the call comprises receiving the user communication in a DS0 format.

20. The method of claim **11** wherein the processing system is external to the communication system.

* * * * *

EXHIBIT J

US007505454B2

(12) **United States Patent**
Christie

(10) **Patent No.: US 7,505,454 B2**
(45) **Date of Patent: Mar. 17, 2009**

(54) **METHOD, SYSTEM AND APPARATUS FOR TELECOMMUNICATIONS CONTROL**

(75) Inventor: **Joseph Michael Christie**, San Bruno, CA (US)

(73) Assignee: **Sprint Communications Company L.P.**, Overland Park, KS (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 179 days.

(21) Appl. No.: **11/560,999**

(22) Filed: **Nov. 17, 2006**

(65) **Prior Publication Data**

US 2007/0076753 A1 Apr. 5, 2007

Related U.S. Application Data

(63) Continuation of application No. 10/633,798, filed on Aug. 4, 2003, now Pat. No. 7,286,561, which is a continuation of application No. 09/082,040, filed on May 20, 1998, now Pat. No. 6,643,282, which is a continuation of application No. 08/568,551, filed on Dec. 7, 1995, now Pat. No. 5,825,780, which is a continuation of application No. 08/238,605, filed on May 5, 1994, now abandoned.

(51) **Int. Cl.**
H04L 12/66 (2006.01)

(52) **U.S. Cl.** **370/352**; 370/466

(58) **Field of Classification Search** .... None
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,491,945	A		1/1985	Turner
4,683,584	A		7/1987	Chang et al.
4,686,669	A		8/1987	Chang
4,686,701	A		8/1987	Ahmad et al.
4,799,153	A		1/1989	Hann et al.
4,991,172	A		2/1991	Cidon et al.
5,029,199	A		7/1991	Jones et al.
5,084,816	A		1/1992	Boese et al.
5,115,426	A		5/1992	Spanke
5,274,698	A		12/1993	Jang
5,297,147	A		3/1994	Shimokasa
5,305,312	A	*	4/1994	Fornek et al. 370/264
5,329,308	A	*	7/1994	Binns et al. 348/14.01
5,339,318	A		8/1994	Tanaka et al.

(Continued)

FOREIGN PATENT DOCUMENTS

AU	200043800	9/2000

(Continued)

OTHER PUBLICATIONS

Manu Bahl, et al.; "The Evolving Intelligent Interexchange Network—An SS7 Perspective;" Proceedings of the IEEE; Apr. 1992; pp. 637-643; vol. 80, No. 4.

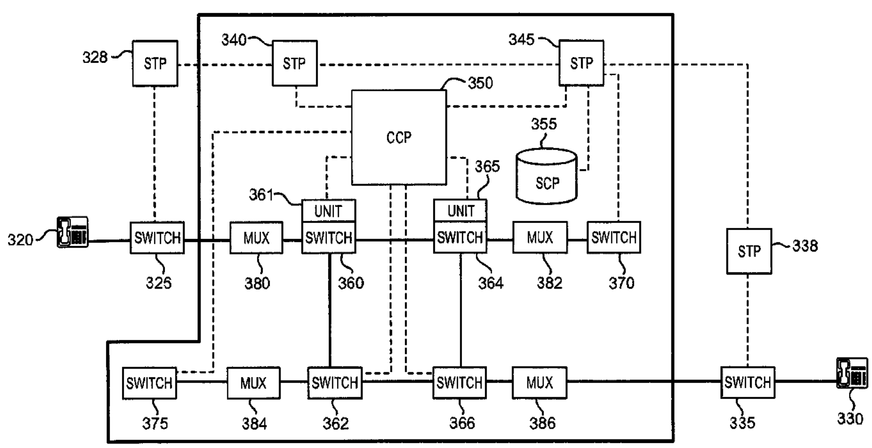
(Continued)

Primary Examiner—Ajit Patel

(57) **ABSTRACT**

The present invention includes a method, system, and apparatus for providing communication control. The invention includes a method in which signaling is processed externally to a switch before it is applied by the network elements. The processor is able to select network characteristics and signal the network elements based the selections. A network employing the processing method is also included, as well as a signaling system that employs the processing method.

14 Claims, 8 Drawing Sheets



U.S. PATENT DOCUMENTS

5,392,402	A *	2/1995	Robrock, II	709/227
5,394,463	A	2/1995	Fischell et al.	
5,434,852	A *	7/1995	La Porta et al.	370/385
5,438,570	A	8/1995	Karras et al.	
5,440,563	A	8/1995	Isidoro et al.	
5,473,679	A	12/1995	La Porta et al.	
5,485,455	A	1/1996	Dobbins et al.	
5,506,894	A	4/1996	Billings et al.	
5,519,770	A	5/1996	Stein	
5,533,115	A	7/1996	Hollenbach et al.	
5,544,163	A	8/1996	Madonna	
5,701,301	A	12/1997	Weisser, Jr.	
RE36,416	E	11/1999	Szlam et al.	
6,324,179	B1 *	11/2001	Doshi et al.	370/395.61
6,847,611	B1	1/2005	Chase et al.	

FOREIGN PATENT DOCUMENTS

EP	0 488 399	6/1992
WO	WO9200642	1/1992

OTHER PUBLICATIONS

Sharp, C.D. et al., "Advanced Intelligent Networks—Now a Reality," Electronics & Communication Engineering Journal, IEE (Jun. 1994), pp. 153-162.
De Prycker, Martin et al., "B-ISDN and the OSI Protocol Reference Model," IEE Network (Mar. 1993), pp. 10-18.
International Telecommunications Union, Telecommunication Standardization Sector, Recommendation I.150, Integrated Services Digital Network (ISDN), General Structure, "B-ISDN Asynchronous Transfer Mode Functional Characteristics," Geneva (Mar. 1993), 12 pages.
International Telecommunication Union, Telecommunication Standardization Sector, Recommendation I.361, Integrated Services Digital Network (ISDN), Overall Network Aspects and Functions, "B-ISDN ATM Layer Specification," Geneva (Mar. 1993), 16 pages.
International Telecommunication Union, The International Telegraph and Telephone Consultative Committee (CCITT), Recommendation I.321, Overall Network Aspects and Functions, "ISDN User-Network Interfaces, B-ISDN Protocol Reference Model and Its Application," Geneva, 1991, 10 pages.
Thorner, Jan, Intelligent Networks, "Chapter 2: Intelligent Networks," Artech House, 1994, pp. 11-35.
Thorner, Jan, Intelligent Networks, "Chapter 6: New Service Demands in the Future," Artech House, 1994, pp. 97-107.
International Telecommunication Union, Telecommunication Standardization Sector, Recommendation Q.1214, General Recommendations on Telephone Switching and Signalling, Intelligent Network, "Distributed Functional Plane for Intelligent Network CS-1," Helsinki (Mar. 1993), 9 pages.
O'Reilly, Peter et al., "Experiences in Prototyping the Intelligent Network," IEEE, 1993, pp. 1923-1930.
Aitken, D. James, "Experiences of Implementation Using Advanced Intelligent Network Release 1 Architecture," Software Engineering for Telecommunication Systems and Services, Logica Space and Communication Ltd., UK, 1992, pp. 19-26.
Salm, Frank et al., "Exploring Intelligent Network Control of Active Calls on a Co Switch," IEEE, 1993, pp. 1558-1562.
International Telecommunication Union, Telecommunication Standardization Sector, Recommendation I.580, Integrated Services Digital Network (ISDN), Internetwork Interfaces, "General Arrangements for Interworking Between B-ISDN and 64 kbit/s Based ISDN," Geneva (Mar. 1993), 25 pages.
International Telecommunication Union, Telecommunication Standardization Sector, Recommendation Q.1204, General Recommendations on Telephone Switching and Signalling, Intelligent Network, "Intelligent Network Distributed Functional Plane Architecture," Geneva (Mar. 1993), 9 pages.
Pinkham, Gary, "Intelligent Network Feature Transaction Interface," IEEE Communications (Dec. 1988), pp. 47-52.
Garrahan, James J. et al., "Intelligent Network Overview," In Standards, IEEE Communications (Mar. 1993), pp. 30-36.
Chau, Sam et al., "Intelligent Network Routing Using CCS7 and ISDN," IEEE Communications, 1990, pp. 1640-1644.
International Telecommunication Union, Telecommunication Standardization Sector, Recommendation Q.1218, General Recommendations on Telephone Switching and Signalling, Intelligent Network, "Interface Recommendation for Intelligent Network CS-1," Geneva (Mar. 1993), 115 pages.
International Telecommunication Union, Telecommunication Standardization Sector, Recommendation Q.1211, General Recommendations on Telephone Switching and Signalling, Intelligent Network, "Introduction to Intelligent Network Capability Set 1," Geneva (Mar. 1993), 34 pages.
Duc, Nguyen Quang et al., "ISDN Protocol Architecture," IEEE Communications (Mar. 1985), vol. 23, No. 3, pp. 15-22.
International Telecommunication Union, Telecommunication Standardization Sector, Recommendation I.320, Integrated Services Digital Network (ISDN), Overall Network Aspects and Functions, "ISDN Protocol Reference Model," Geneva (Nov. 1993), 16 pages.
Stallings, William, Networking Standards: A Guide to OSI, ISDN, LAN, and MAN Standards, "Chapter 4: Internetworking," Addison-Wesley Publishing Company, Feb. 1993, pp. 1-2, 99-112.
Hughes, C.J. et al., "Packet Power: B-ISDN and the Asynchronous Transfer Mode," IEE Review, Oct. 1991, pp. 357-360.
International Telecommunication Union, Telecommunication Standardization Sector, Recommendation X.219, Open Systems Interconnection, Service Definitions, "Remote Operations: Model, Notation and Service Definition," Helsinki, 1993, 43 pages.
Stallings, William, ISDN & Broadband ISDN, "Chapter 11: Signaling System No. 7," Macmillan Publishing Company, second edition, New York, 1992, pp. 433-440, 471-485.
International Telecommunication Union, Telecommunication Standardization Sector, Recommendation Q.771, Specifications of Signalling System No. 7, "Signalling System No. 7—Functional Description of Transaction Capabilities," Helsinki (Mar. 1993), 36 pages.
International Telecommunication Union, Telecommunication Standardization Sector, Recommendation Q.773, Specifications of Signalling System No. 7, "Signalling System No. 7—Transaction Capabilities Formats and Encoding," Helsinki, 1993, 37 pages.
International Telecommunication Union, Telecommunication Standardization Sector, Recommendation Q.772, Specifications of Signalling System No. 7, "Signalling System No. 7—Transaction Capabilities Information Element Definitions," Helsinki, 1993, 10 pages.
International Telecommunication Union, Telecommunication Standardization Sector, Recommendation Q.774, Specifications of Signalling System No. 7, "Signalling System No. 7—Transaction Capabilities Procedures," Helsinki, 1993, 63 pages.
Cheung, Nim K., "The Infrastructure for Gigabit Computer Networks," B-ISDN Public Network, IEEE Communications (Apr. 1992), pp. 60-68.
Robrock, II, Richard B., "The Intelligent Network—Changing the Face of Telecommunications," Proceedings of the IEEE, vol. 79, No. 1 (Jan. 1991), pp. 7-20.
International Telecommunication Union, Telecommunication Standardization Sector, Recommendations Q.251-Q.300, Series Q: Switching and Signalling, "Specifications of Signalling System No. 6," Melbourne (Nov. 1988), 145 pages.
International Telecommunications Union, Telecommunication Standardization Sector, Recommendation Q.400-Q.490, Series Q: Switching and Signalling, "Specifications of Signalling System R2," Geneva (Nov. 1988), 117 pages.
Barberis, G. et al., "Progress on the Development and Introduction of ISDN in the Linea UT," XIII International Switching Symposium, Stockholm, Sweden, 1990, pp. 67-74.
"Telecommunications Network Management into the 21st Century: Techniques, Standards, Technologies, and Applications," IEEE Press, Piscataway, New Jersey, 1993, 18 pages.
Mikelaitis, P., "A Tutorial on ISDN Customer Call Control: Part 1," Telecommunication Journal of Australia, vol. 38, No. 1, 1988, pp. 75-92.

Mikelaitis, P., "A Tutorial on ISDN Customer Call Control: Part 2," Telecommunication Journal of Australia, vol. 38, No. 2, 1988, pp. 79-88.

International Telecommunication Union, The International Telegraph and Telephone Consultative Committee (CCITT), Recommendation M.3010, Maintenance: Telecommunications Management Network, "Principles for a Telecommunications Management Network," Melbourne, (Oct. 1992), 69 pages.

International Telecommunication Union, The International Telegraph and Telephone Consultative Committee (CCITT), Recommendation E.170, Telephone Network and ISDN: Operation, Numbering, Routing and Mobile Service, "Traffic Routing," Melbourne, (Oct. 1992), 10 pages.

Barberis, G. et al., "Evolving High Speed Packet Capabilities in a Distributed Switching System," IEEE, 1988, pp. 87-92.

Cazzaniga, Maurizio et al., "Implementation of SS7: Italtel's Experience," IEEE Communications (Jul. 1990), pp. 84-88.

International Telecommunication Union, Telecommunication Standardization Sector, Recommendation Q.2763, B-ISDN Application Protocols of the Network, "Broadband Integrated Services Digital Network (B-ISDN) - Signalling System No. 7 B-ISDN User Part (B-ISUP) - Formats and Codes," Geneva (Feb. 1995), 93 pages.

International Telecommunication Union, Telecommunication Standardization Sector, Recommendation Q.931, Digital Subscriber Signalling System No. 1 Network Layer, "Digital Subscriber Signalling System No. 1 (DSS1) - ISDN User-Network Interface Layer 3 Specification for Basic Call Control," Helsinki (Mar. 1993), 322 pages.

International Telecommunication Union, Telecommunication Standardization Sector, Recommendation Q.763, Specifications of Signalling System No. 7, "Formats and Codes of the ISDN User Part of Signalling System No. 7," Helsinki (Mar. 1993), 89 pages.

International Telecommunication Union, Telecommunication Standardization Sector, Recommendation Q.764, Specifications of Signalling System No. 7, "Signalling System No. 7 - ISDN User Part Signalling Procedures," Helsinki (Mar. 1993), 92 pages.

International Telecommunication Union, Telecommunication Standardization Sector, Recommendation Q.704, Specifications of Signalling System No. 7, "Signalling System No. 7 - Signalling Network Functions and Messages," Helsinki (Mar. 1993), 207 pages.

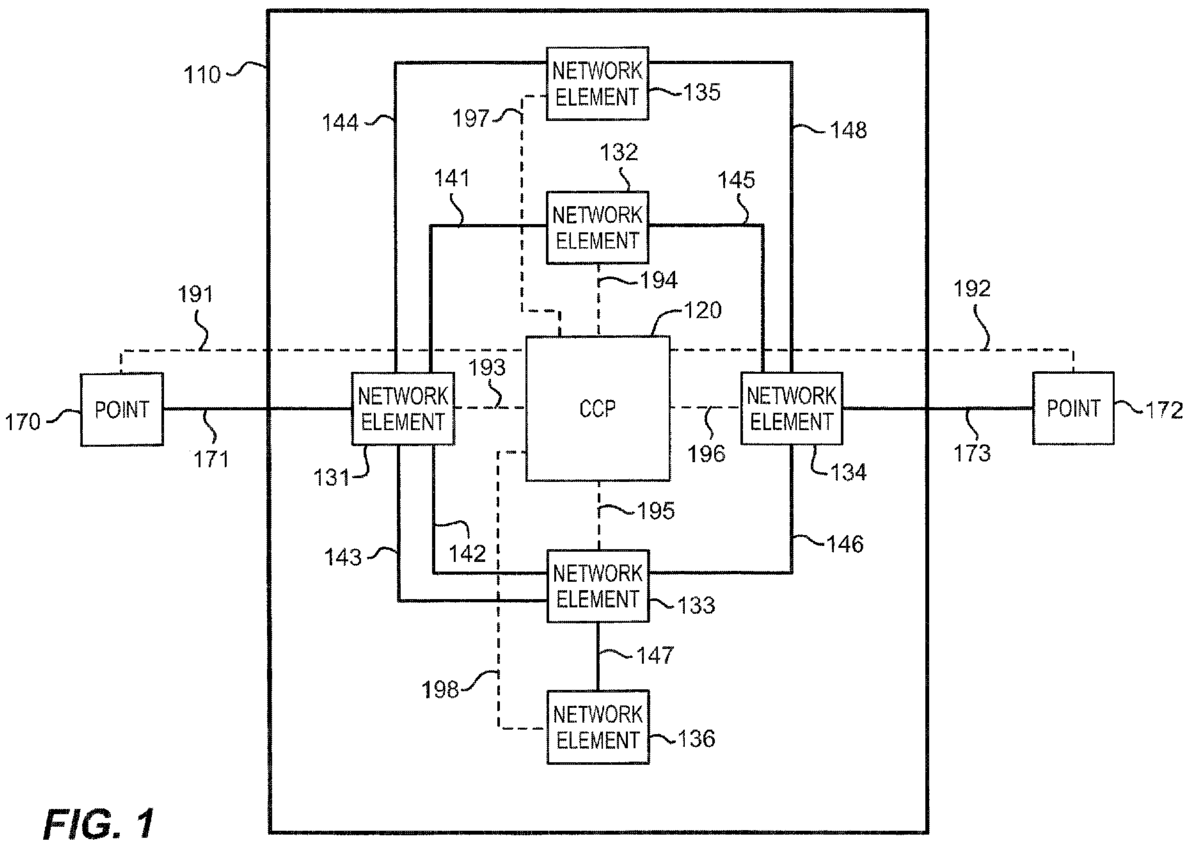
International Telecommunication Union, Telecommunication Standardization Sector, Recommendations Q.251-Q.300, Series Q: Switching and Signalling, "Specifications of Signalling System No. 6," Melbourne (Nov. 1988), 145 pages.

International Telecommunication Union, Telecommunication Standardization Sector, Recommendations Q.400-Q.490, Series Q: Switching and Signalling, "Specifications of Signalling System R2," Geneva (Nov. 1988), 117 pages.

Barberis, G. et al., "Progress on the Development and Introduction of ISDN in the Linea UT," XIII International Switching Symposium, Stockholm, Sweden, 1990, pp. 67-74.

"Telecommunications Network Management into the 21st Century: Techniques, Standards, Technologies, and Applications," IEEE Press, Piscataway, New Jersey, 1993, 18 pages.

* cited by examiner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CCP
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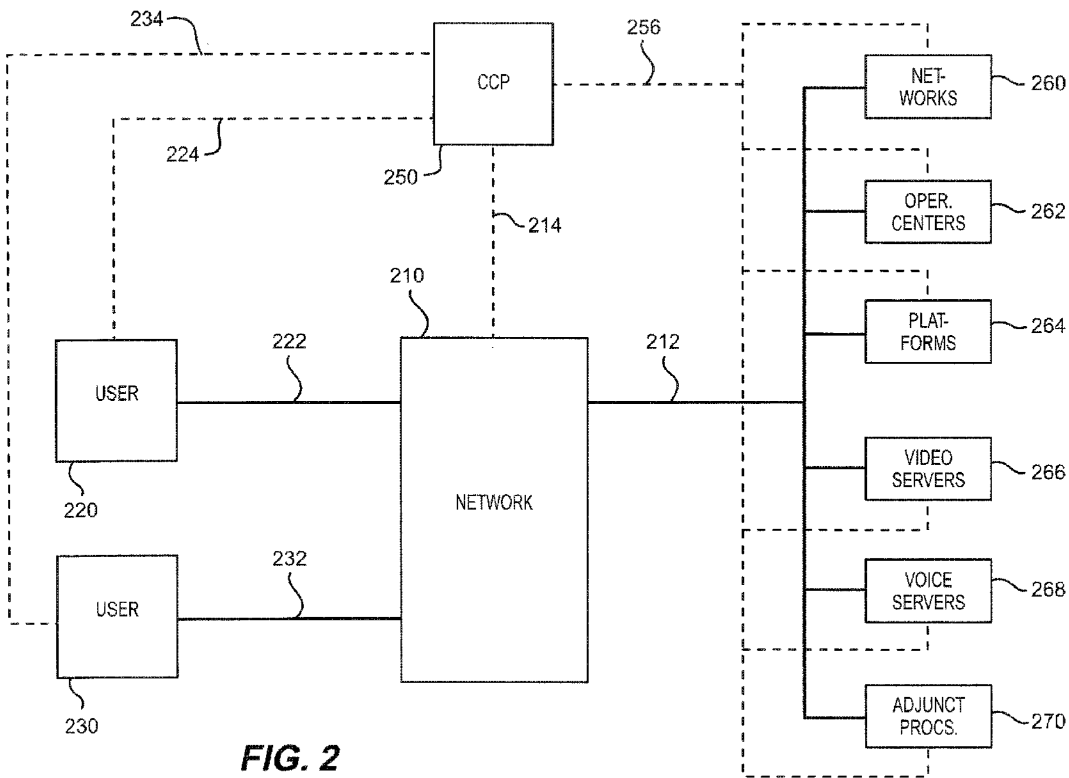
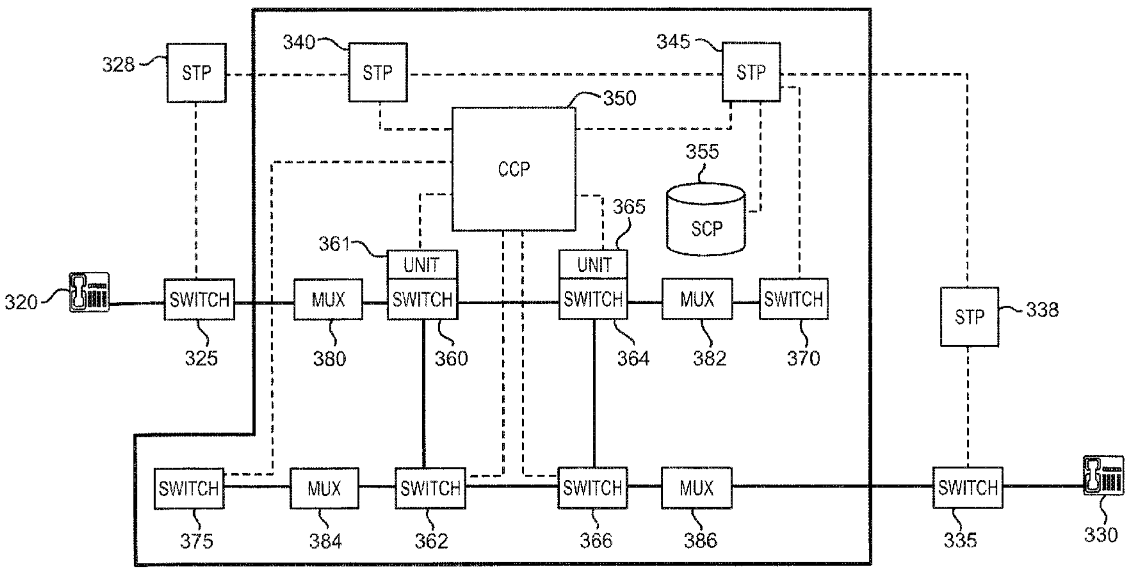
FIG. 1



234
CCP
256
224
250
214
210
222
212
USER
NETWORK
220
232
USER
230
NET-
WORKS
260
OPER.
CENTERS
262
PLAT-
FORMS
264
VIDEO
SERVERS
266
VOICE
SERVERS
268
ADJUNCT
PROCS.
270

FIG. 2



328
STP
340
STP
345
STP
350
CCP
355
SCP
365
361
UNIT
UNIT
320
SWITCH
MUX
SWITCH
SWITCH
MUX
SWITCH
STP
338
325
380
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FIG. 3

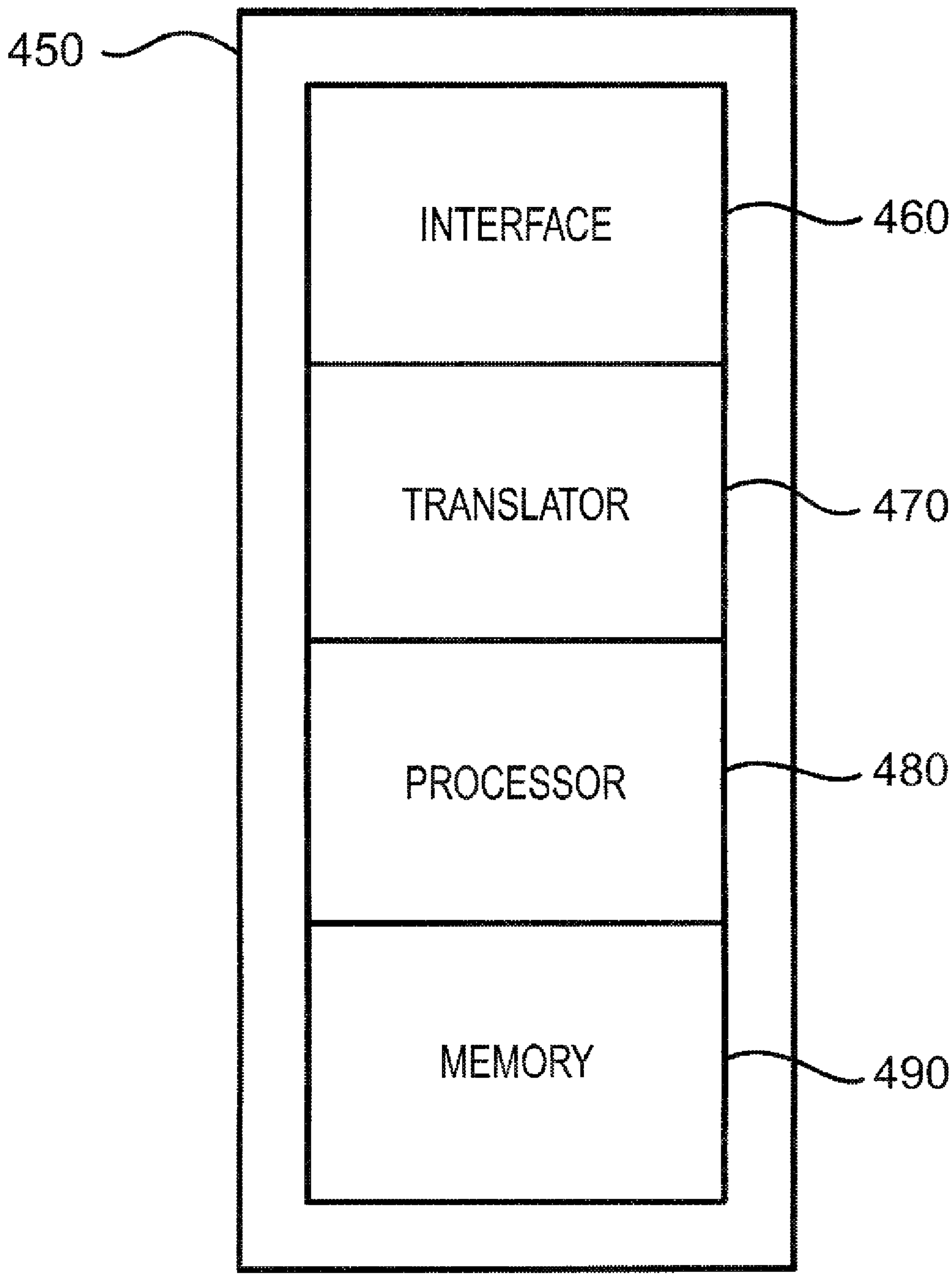
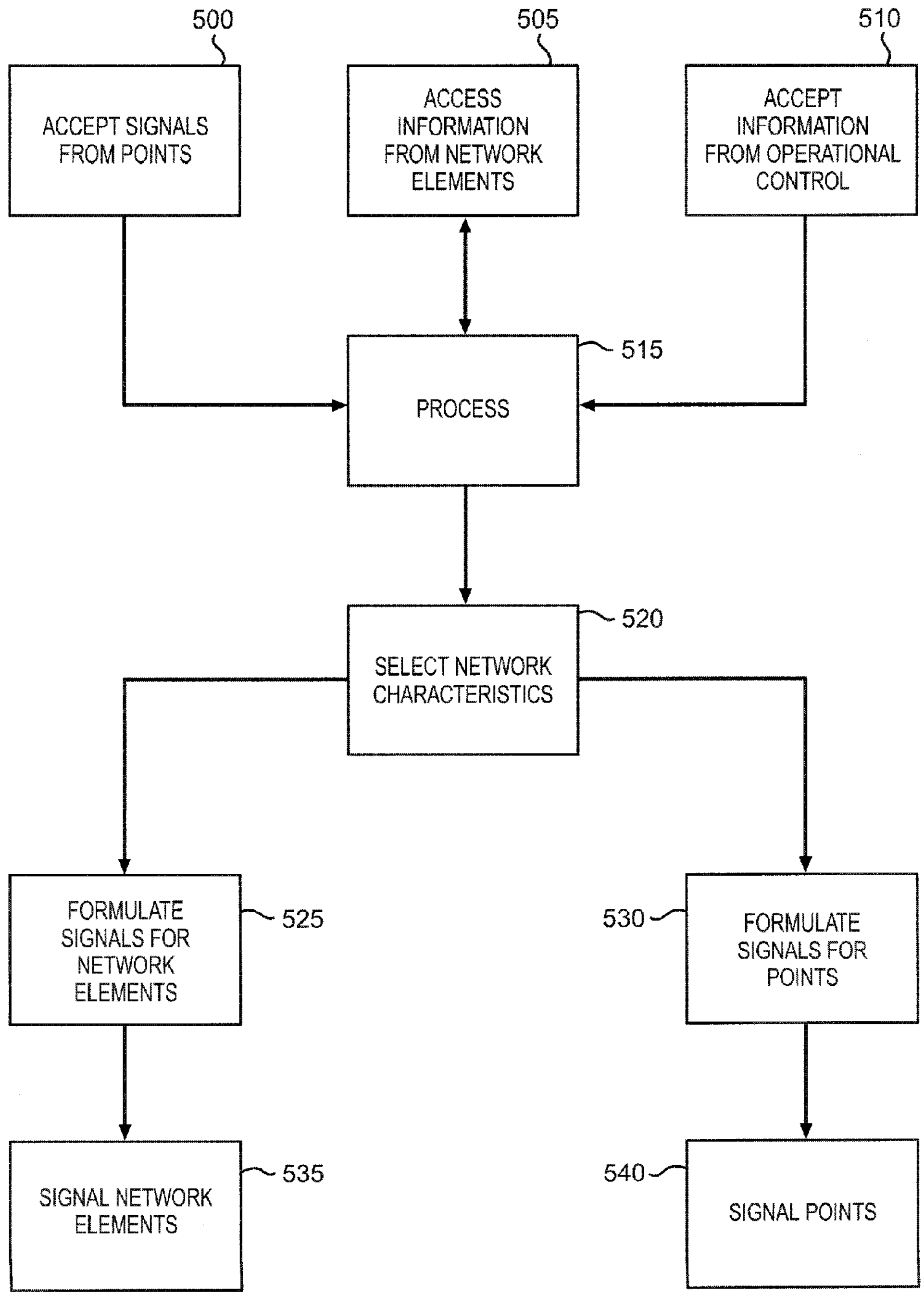


FIG. 4



500
ACCEPT SIGNALS FROM POINTS
505
ACCESS INFORMATION FROM NETWORK ELEMENTS
510
ACCEPT INFORMATION FROM OPERATIONAL CONTROL
515
PROCESS
520
SELECT NETWORK CHARACTERISTICS
525
FORMULATE SIGNALS FOR NETWORK ELEMENTS
530
FORMULATE SIGNALS FOR POINTS
535
SIGNAL NETWORK ELEMENTS
540
SIGNAL POINTS

FIG. 5

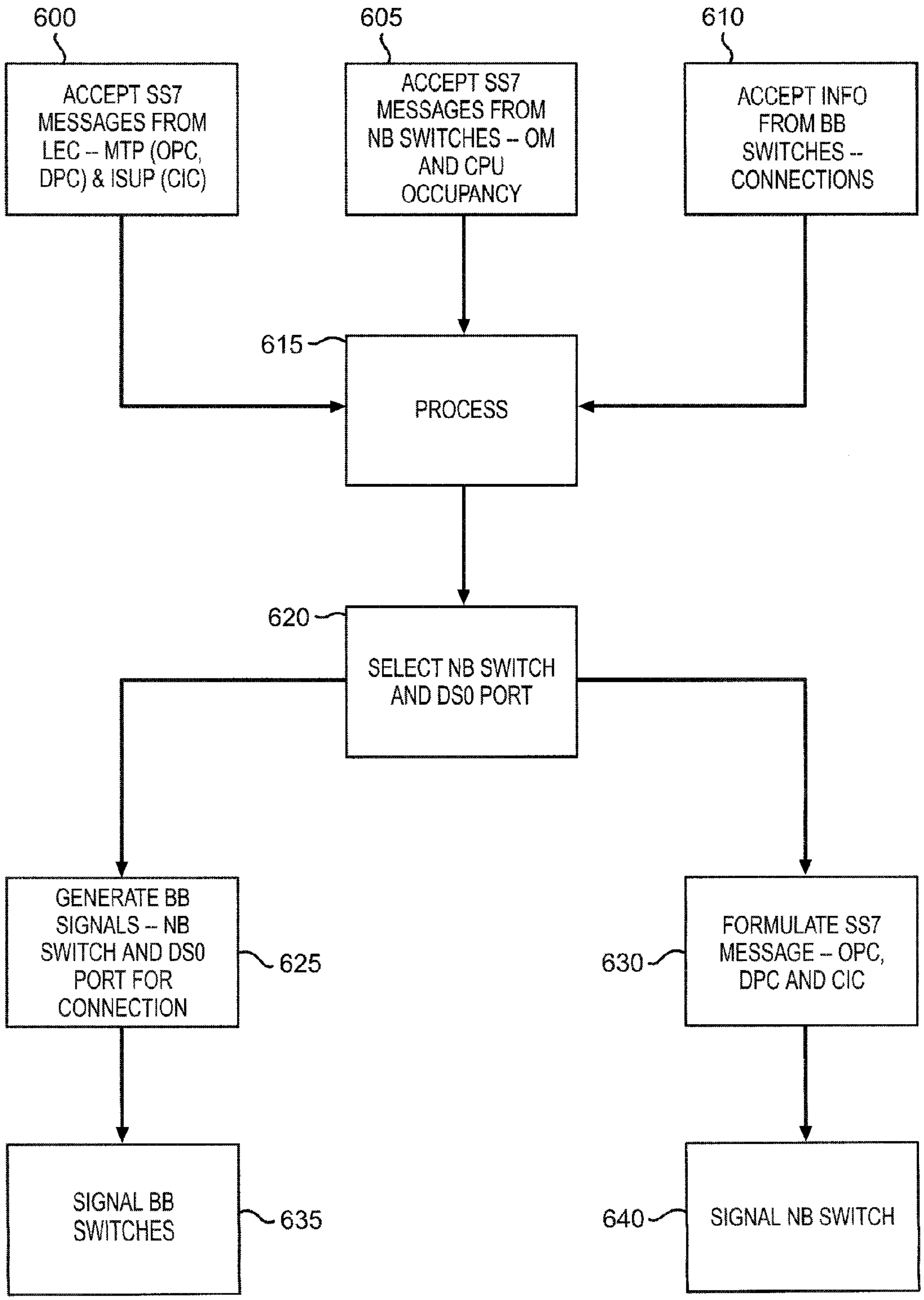

600
ACCEPT SS7 MESSAGES FROM LEC -- MTP (OPC, DPC) & ISUP (CIC)
605
ACCEPT SS7 MESSAGES FROM NB SWITCHES -- OM AND CPU OCCUPANCY
610
ACCEPT INFO FROM BB SWITCHES -- CONNECTIONS
615
PROCESS
620
SELECT NB SWITCH AND DS0 PORT
GENERATE BB SIGNALS -- NB SWITCH AND DS0 PORT FOR CONNECTION
625
630
FORMULATE SS7 MESSAGE -- OPC, DPC AND CIC
SIGNAL BB SWITCHES
635
640
SIGNAL NB SWITCH

FIG. 6

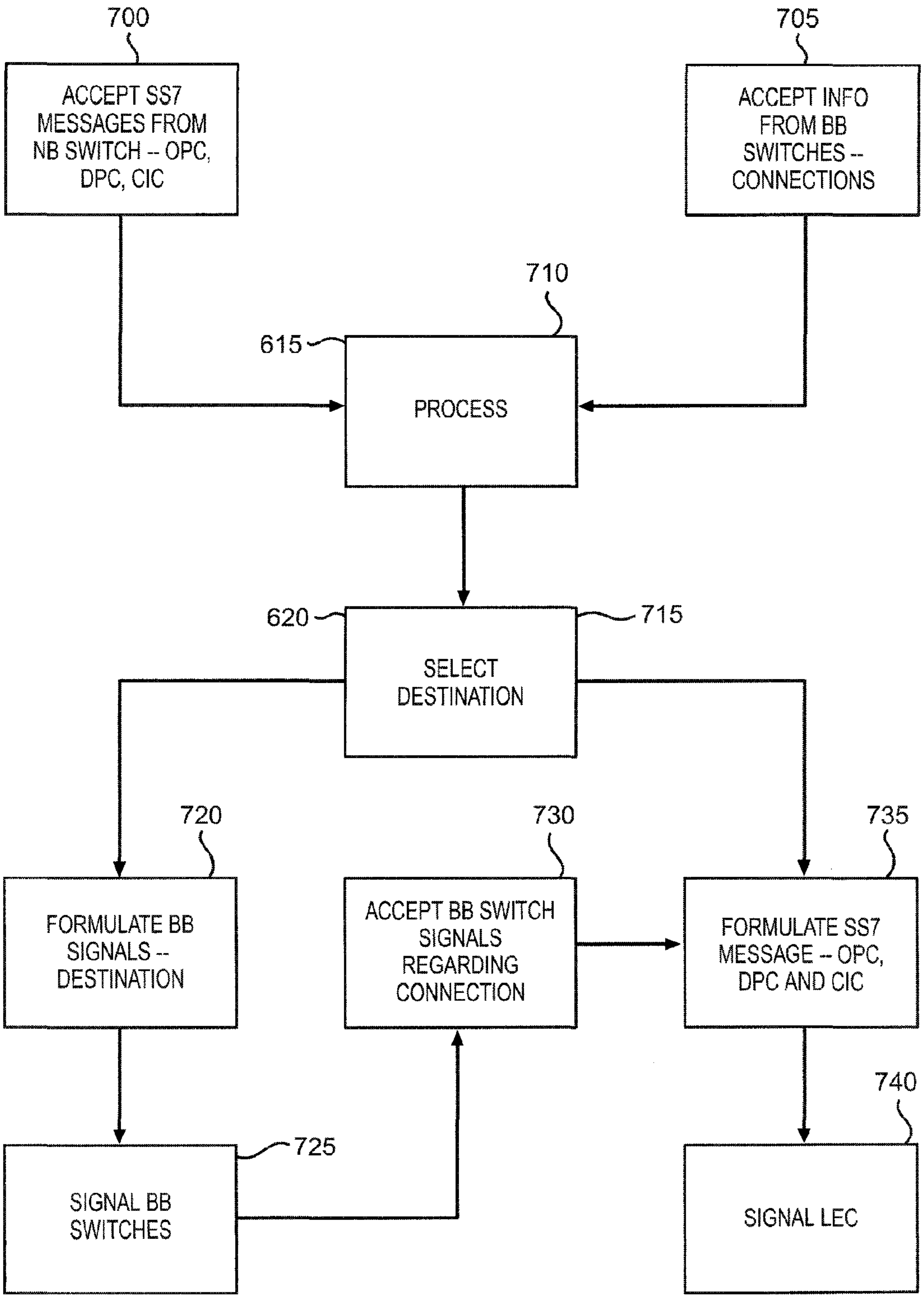
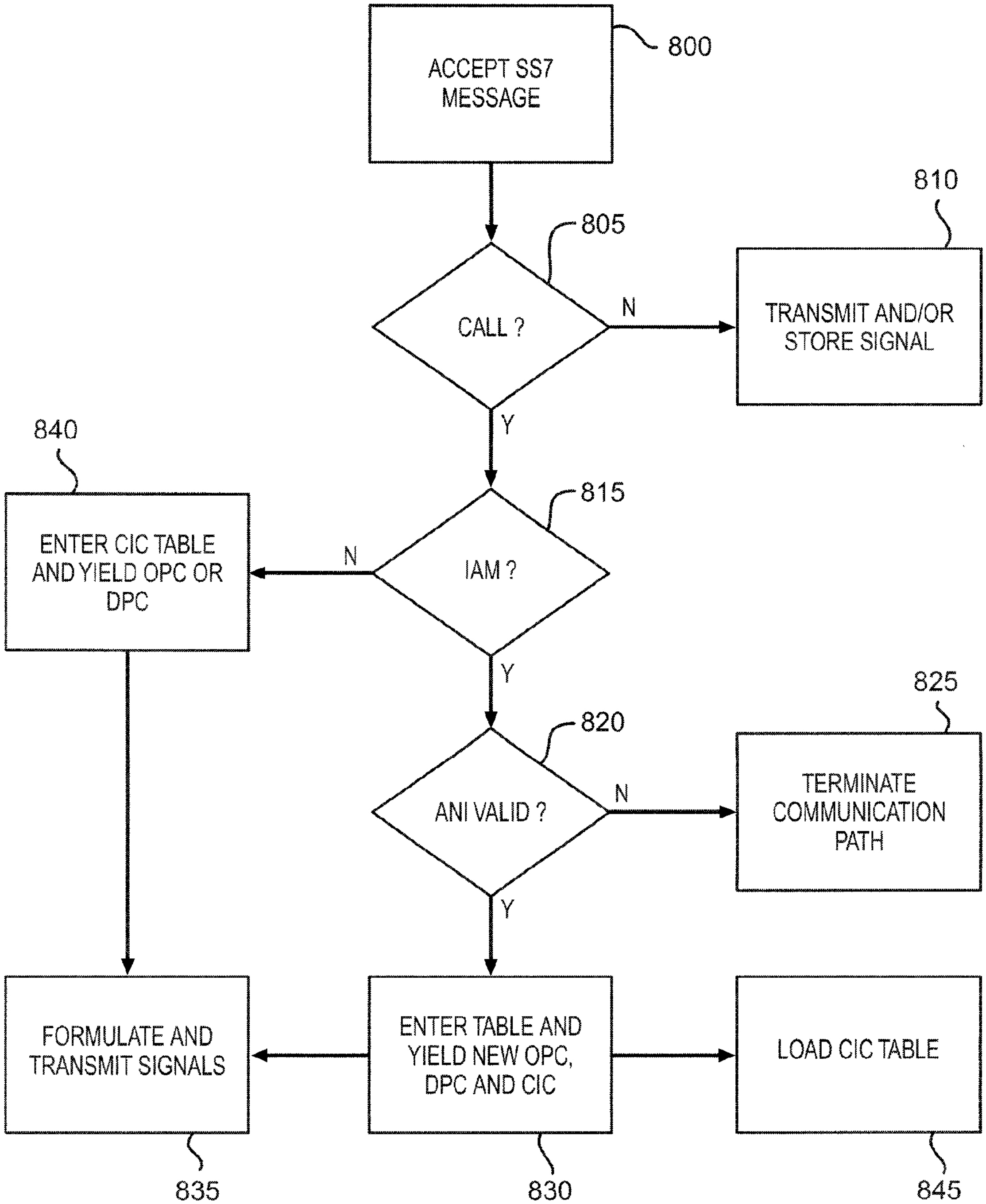

700
ACCEPT SS7 MESSAGES FROM NB SWITCH -- OPC, DPC, CIC
705
ACCEPT INFO FROM BB SWITCHES -- CONNECTIONS
710
615
PROCESS
620
715
SELECT DESTINATION
720
730
735
FORMULATE BB SIGNALS -- DESTINATION
ACCEPT BB SWITCH SIGNALS REGARDING CONNECTION
FORMULATE SS7 MESSAGE -- OPC, DPC AND CIC
740
725
SIGNAL BB SWITCHES
SIGNAL LEC

FIG. 7



ACCEPT SS7 MESSAGE
800
CALL ?
805
N
Y
TRANSMIT AND/OR STORE SIGNAL
810
840
ENTER CIC TABLE AND YIELD OPC OR DPC
IAM ?
815
N
Y
ANI VALID ?
820
N
Y
TERMINATE COMMUNICATION PATH
825
FORMULATE AND TRANSMIT SIGNALS
ENTER TABLE AND YIELD NEW OPC, DPC AND CIC
LOAD CIC TABLE
835
830
845

FIG. 8

METHOD, SYSTEM AND APPARATUS FOR TELECOMMUNICATIONS CONTROL

RELATED APPLICATIONS

This application is a continuation of co-pending U.S. patent application Ser. No. 10/633,798 filed on Aug. 4, 2003, which is a continuation of U.S. Pat. No. 6,643,282, issued on Nov. 4, 2003, which is a continuation of U.S. Pat. No. 5,825,780, issued on Oct. 20, 1998, which is a continuation of U.S. patent application Ser. No. 08/238,605, filed on May 5, 1994 and now abandoned. U.S. Pat. No. 5,825,780 is hereby incorporated by reference into this application.

FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not applicable

MICROFICHE APPENDIX

Not applicable

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to telecommunications and more specifically to communications control processing in telecommunications signaling.

2. Description of the Prior Art

Telecommunications systems establish a communications path between two or more points to allow the transfer of information between the points. The communications path typically comprises a series of connections between network elements. The network elements are typically switches. Switches provide the primary means where different connections are associated to form the communications path. Communication control is the process of setting up a communications path between the points. Communication control comprises the selection of network elements such as switches or other devices which will form part of the communications path. Communication control also comprises the selection of the connections between the network elements. Together, control also comprises the selection of the connections between the network elements. Together, the network elements and connections which are selected make up the communications path. Typically, a plurality of different network element and connection selections may be possible for any one communications path between points.

Switches control these selections. Switches select the connections that comprise the communications path. Switches also select the network elements which form an actual part of that communications path. By selecting these network elements, a switch is often selecting the next switch that will make further selections. Switches accomplish communication control.

The correspondence between communication control and a communications path is well known in the art. A common method used in communication control is signaling among switches. One method by which a first point requests a communications path to a second point is by signaling a first switch with an off-hook signal followed by dual tone multi-frequency (DTMF) signals. The first switch will typically process those signals and will select other network elements such as a second switch. The first switch signals the second switch and establishes a connection between the switches. The second switch then selects the next network element, signals that network element, and establishes a connection to that network element. This process is well known in the art. The connections and signaling thus proceed from switch to switch through the network until a communications path is established between the first and second points.

Some networks transmit signaling information from the switches to other signaling devices. In these cases, the switches typically must be modified through the use of Signaling Point (SP) hardware and software in order to convert the language of the switch into the language used by these other signaling devices. One signaling device is a Service Control Point (SCP). An SCP processes signaling queries from a switch. An SCP only answers a switch query after the switch has become a part of the communications path. SCPs support the communication control which is directed by the switch.

Additionally, signaling may pass through other signaling devices, such as Signal Transfer Points (STPs), which route the signaling. An STP is typically, a high-speed packet data switch which reads portions of the signaling information and either discards or routes the information to a network element. The signal routing operation of the STP is based on the signaling information that is specified by the switch. STPs route signaling information, but STPs do not modify or otherwise process the signaling information. An example of the above described system is Signaling System #7 (SS7) technology. Thus, signaling devices only are used to support switches in communication control.

Broadband systems, such as Asynchronous Transfer Mode (ATM) may use extensions of existing SS7 signaling to allow ATM switches to direct communication control. However, broadband systems may also utilize different communication control methods. ATM switches may transfer ATM cells which contain signaling to other ATM switches. As with the other switch types however, ATM switches also perform the dual task of communication control and forming a part of the communications path.

Some switches use API switching which employs remote central processing units (CPUs). These switches only receive switch information from the remote CPUs and not signaling. The protocols used for information transfer between the switch and the remote CPU are proprietary among vendors and are incompatible between the switches of different vendors.

Some digital cross-connect (DCS) equipment employ centralized control systems. These systems, however, only provide relatively static switching fabrics and do not respond to signaling. Instead of establishing connections in response to signaling, DCS cross-connections are established in response to network configuration needs. Network elements and connections are pre-programmed into the network and are not selected in response to signaling from a point outside of the network.

At present, while communication control and the communications path are distinct from one another, both are dependent on the switch. The performance of both of these tasks by switches places limitations on a telecommunications network. One such limitation can be illustrated by one difficulty encountered in combining narrowband networks and broadband networks. Broadband networks are advantageous for data transmission because virtual permanent connections can be mapped through a network and bandwidth allocated on demand. Narrowband switches are advantageous for voice, in part, due to the many features which have been developed in conjunction with these switches. These features benefit both the user and the network through added efficiency and quality. Examples are "800" platforms, billing systems, and routing

systems. However for broadband networks, the development of these features is incomplete and does not provide the functionality of current narrowband features. Unfortunately, narrowband switches do not have the capacity, speed, and multimedia capabilities of broadband switches. The resulting combination is separate overlay networks. Typically, narrowband traffic remains within the narrowband network, and broadband traffic remains within the broadband network.

Any intelligent interface between the two networks would require that signaling information be transmitted between narrowband switches and broadband switches. At present, the ability of these switches to signal each other is limited. These switch limitations create a major obstacle in any attempt to interface the two networks. It would be advantageous if narrowband and broadband networks could interwork through an intelligent interface to establish a communications path between points. At present, the interface between narrowband and broadband networks remains a rigid access pipe between overlay systems.

The reliance on switches to both perform communication control and to form the a part of the communications path results in impediments to developing improved networks. Each time a new network element, such as a broadband switch, is introduced, a telecommunications network may be forced to delay integrating the network element into its network until standardization of signaling and interface protocols are developed for the switches. At present, there is a need for a portion of the communication control processing to be independent of the switches that form a part of the communications path.

SUMMARY

An embodiment of the present invention solves this need by providing a method, system, and apparatus for communication control processing that is located externally to the switches that make the connections. The method includes receiving a first signal into a processor which is located externally to the switches in a network comprised of network elements. The processor selects a network characteristic in response to the first signal. The processor then generates a second signal reflecting the network characteristic and transmits the second signal to at least one network element. This transmission occurs before that network element has applied the first signal. Examples of network characteristics are network elements and connections, but there are others. Examples of signaling are Signaling System #7 or broadband signaling. The processor may also employ information received from the network elements or operational control when making selections. In one embodiment, the method includes receiving the first signal into a network from a point and routing the first signal to the processor.

The present invention also includes a telecommunications processing system which comprises an interface that is external to the switches and is operational to receive and transmit signaling. The processing system also includes a translator that is coupled to the interface and is operational to identify particular information in the received signaling and to generate new signaling based on new information. The processor also includes a processor that is coupled to the translator and is operational to process the identified information from the translator in order to select at least one network characteristic. The processor provides new information to the translator reflecting the selection. The identified information is used in the processor before it is used in the particular network elements that receive the new signaling.

The present invention also includes a telecommunications network comprised of a plurality of network elements wherein at least one network element is a switch, and a plurality of connections between the network elements. The network also includes a processor located externally to the switches which is operable to receive a first signal, to select at least one network characteristic in response to the first signal, and to generate a second signal reflecting the selection. The network also includes a plurality of links between the processor and the network elements which are operable to transmit the second signal to at least one network element before that network element has applied the first signal.

The present invention also includes a telecommunications signaling system for use in conjunction with a plurality of telecommunication switches. This system comprises a plurality of signaling points and a signaling processor. The signaling processor is linked to the signaling points and resides externally to the switches. The signaling processor is operational to process signaling and to generate new signaling information based on the processing. The new signaling is transmitted over the links to multiple signaling points. In one embodiment, the new signaling information is comprised of different signaling messages and the different signaling messages are transmitted to different signaling points.

In another embodiment, a plurality of the signaling points each reside in a different switch and are directly coupled to a processor in the switch that directs a switching matrix in the switch in response to signaling processed by the signaling point. The signaling processor is operational to direct the switching matrixes of multiple switches by signaling multiple signaling points. The signaling processor is also operational to signal multiple points in response to signaling from a single source, and to signal a point in response to signaling from multiple sources.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features, aspects, and advantages of the present invention will become better understood with regard to the following description, claims, and drawings where:

FIG. **1** is a block diagram of a version of the invention.
FIG. **2** is a block diagram of a version of the invention.
FIG. **3** is a block diagram of a version of the invention.
FIG. **4** is a logic diagram of a version of the invention.
FIG. **5** is a flow diagram of a version of the invention.
FIG. **6** is a flow diagram of a version of the invention.
FIG. **7** is a flow diagram of a version of the invention.
FIG. **8** is a flow diagram of a version of the invention.

DESCRIPTION

Telecommunications systems establish communications paths between points which allow the points to transfer information, such as voice and data, over the communication paths. Typically, telecommunications systems are comprised of network elements and connections. A network element is a telecommunications device such as a switch, server, service control point, service data point, enhanced platform, intelligent peripheral, service node, adjunct processor, network element of a different network, enhanced system or other network related device, server, center or system.

A connection is the media between two network elements that allows the transfer of information. A few examples of connections are: digital T1 lines, OC-3 optical fibers, packet connections, dedicated access lines, microwave transmission, and cellular radio. As those skilled in the art are aware, connections can be described in a range from general to specific.

All of the media between two switches is a general description and might correspond to a virtual path in an ATM system or a trunk groups in a T1 system. An individual circuit between two elements is more specific and might correspond to a virtual channel in an ATM system or a DS0 circuit in a T1 system. Connections can also be described as being logical or physical. Physical connections are electrical-mechanical media. Logical connections are paths which follow physical connections, but are differentiated from one another based on format and protocol. The term "connection" includes this entire range and the meaning varies according to the context in which the term is used. The present invention could make selections encompassing the entire range of connections.

A communications path is the combination of connections and network elements that physically transfers the information between points. A communication path may be point to point, point to multi-point, or multi-point to multi-point. These points, in turn, define the ends of the communications path. Thus, a connection may also be made between a network element and a point outside the network.

Signaling is the transfer of information among points and network elements and is used to establish communications paths. An example is Signaling System #7 (SS7). Signaling is typically transmitted over links, such as 56 kilobit lines. On the block diagrams, signaling is represented by dashed lines and connections are represented by solid lines.

In FIG. **1**, Telecommunications System **110** comprises a communication control processor (CCP) **120** and first, second, third, fourth, fifth and sixth network elements, **131**, **132**, **133**, **134**, **135** and **136** respectively. First and second network elements, **131** and **132** respectively, are connected by first connection **141**. First and third network elements, **131** and **133** are connected by both second and third connections, **142** and **143** respectively. First and fifth network elements, **131** and **135** respectively, are connected by fourth connection **144**. Second and fourth network elements, **132** and **134** are connected by fifth connection **145**. The third network element **133** is connected to fourth and sixth network elements, **134** and **136** by sixth and seventh connections, **146** and **147** respectively. Fourth and fifth network elements, **134** and **135** are connected by connection **148**. A first point **170**, which is located outside of the system **110**, is connected to first element **131** by first point connection **171**, and a second point **172** which is also located outside the system **110** is connected to fourth element **134** by second point connection **173**. First and second points, **170** and **172** respectively and first, second, third, fourth, fifth and sixth elements **131**, **132**, **133**, **134**, **135**, and **136** respectively each are linked to CCP **120** by first, second, third, fourth, fifth, sixth, seventh, and eighth links, **191**, **192**, **193**, **194**, **195**, **196**, **197** and **198** respectively.

As those skilled in the art are aware, a system is typically comprised of many more network elements, links, connections and points, but the number is restricted for clarity. Points outside of the network can take many forms, such as customer premises equipment (CPE), telephones, computers, or switches of a separate network system. In addition the system **110**, may take many forms such as international gateways, satellite networks, wireless networks, local exchange carriers (LECs), inter-exchange carriers (IXCs), transit networks, national networks, personal communicator systems (PCS), virtual private networks, or connection oriented networks such as local area networks (LANs), metropolitan area networks (MANs), wide area networks (WANs) to name some examples.

In operation Telecommunications System **110** is able to accept information from first point **170** and second point **172** and transmit the information over the various network elements and connections which form the communications path. System **110** is also capable of exchanging signaling with first point **170** and second point **172** over the first link **191** and second link **192**.

On a standard call that establishes a communications path from first point **170** to second point **172**, first point **170** will signal Telecommunications System **110** that it requests the communications path. This signaling is directed to CCP **120** over first link **191**. CCP **120** processes the signaling and selects at least one network characteristic in response to the signaling. Network characteristics might be network elements, connections, network codes, applications, or control instructions to name a few examples. The selected network characteristic typically comprises one of a plurality of network elements and/or connections. The CCP **120** generates signaling which is preferably new signaling reflecting the selection. CCP **120** then transmits the signal to at least one of a plurality of network elements before that network element has applied the signal.

In one embodiment, CCP **120** selects the network elements and the connections that comprise the communications path. However, first point **170** will typically seize first point connection **171** contemporaneously with signaling. This initial connection could also be selected by CCP **120** from the available possibilities after the signaling by first point **170**. Assuming first point **170** has seized first point connection **171** to first element **131**, CCP **120** selects one, a plurality, or all of the remaining network elements and connections to further establish a communications path to second point **172**.

CCP **120** determines which element should be connected to first element **131**. CCP **120** could select either second element **132** or third element **133**. If third element **133** is selected, CCP **120** may also select the connection to third element **133** from among second and third connections, **142** and **143** respectively. If third connection **143** is selected, CCP **120** will signal first element **131** over third link **193** to further the communications path to third element **133** over third connection **143**.

CCP **120** may then make further selections to complete the communications path. As the possibilities have been limited for clarity, CCP **120** would make the selections and signal the elements as follows. CCP **120** would signal third element **133** over fifth link **195** to further the communications path to fourth element **134** over sixth connection **146**. CCP **120** would signal fourth element **134** over sixth link **196** to further the communications path to second point **172** over second point connection **173**. CCP **120** would also signal second point **172** over second link **192** of the communications path available through second point connection **173**. In this way, the communications path requested by first point **170** is selected by CCP **120** and signaled to the elements. Throughout this process, CCP **120** may receive status messages and signaling from the elements to support its processing. This status messaging may be transmitted and received over links, connections, or other communication means.

In another embodiment, CCP **120** may select only the network elements and not the connections. The elements would select the connections to use based on the network element selected by CCP **120**. For this embodiment, the main difference from the above example is that CCP **120** would instruct first element **131** to further the communications path to third element **133**, but first element **131** would select the actual connection used from among second and third connections, **142** and **143**, respectively. First element **131** may signal CCP **120** over third link **193** of its selection so that CCP **120** may signal third element **133** of the connection over fifth link **195**. In this embodiment, CCP **120** would specify the network

elements to the elements, which in turn, would select the connections between these network elements.

There are situations in which the selection of a network element and the selection of a connection signify the same thing. On FIG. **1** for example, instructing first element **131** to use first connection **141** is synonymous with an instruction to connect to second element **132**. This is because the connection inevitably connects to the element. The selection of a connection may effectively select a network element, and the selection of a network element may effectively select a connection (or a group of specific connections) to that network element.

One skilled in the art will recognize that the selection process can be distributed among the CCP and the elements. The CCP might select all the network elements, a portion of the network elements, or none of the network elements leaving the switches to select the remainder. The CCP might select all of the connections, a portion of the connections, or none of the connections, again leaving the elements to select the remainder. The CCP may select combinations of the above options, but the CCP will always select at least one network characteristic.

In another embodiment, first point **170** may want to access a other network elements such as servers, platforms or operator centers. For example, such elements could be located at either fifth or sixth network elements **135**, and **136** respectively. CCP **120** will receive signaling from first point **170** over first link **191** indicating this request, and first point **170** will typically seize first point connection **171** to first element **131**. Again CCP **120** will select network elements. If sixth element **136** is selected CCP **120** could select a communications path from first element **131** through either second element **132** to fourth element **134** and then to third element **133**, or through a direct connection from first element **131** to third element **133**. If CCP **120** selects the latter, it would signal first element **131** to further the communications path to third element **133**, and it would signal third element **133** to further the communications path to sixth element **136**. As discussed in the above embodiments, CCP **120** may also select the connections, or the elements may be left with that task.

As is known in the art, in-band signaling is typically used in many user to network connections, such as the local loop. This is because only one connection or link is typically provided to the user premises and thus, the signaling must be placed on the actual communications path. The initial network switch typically removes the signaling from the communications path and transfers it to an out-of-band signaling system. The current invention is fully operational in this context. Although the switch may receive the signaling initially, it will only route the signaling to the CCP for processing. Even if in-band signaling is used within the network, the switches could remove signaling from the communications path and route it to the CCP for processing in accord with the present invention.

Thus, preferably the CCP processes signaling before it is applied or processed by the switch such as to select connections or generate queries. Preferably, no or minimal changes are made to the signaling prior to the signaling being received by the CCP so that the CCP receives the signaling in the same format as a switch would receive the signaling. The CCP may also process the signaling in that format. The switches make their selections based on the CCP selections, thus the switch selections clearly occur after the CCP has processed the signaling. As such, the switch may route signaling to the CCP, but the switch does not apply the signaling. Some examples of a switch applying the signaling would be selecting network elements or generating queries for remote devices.

In one of the above embodiments, the switches did not select the network elements and connections, initiate the signaling, or otherwise control the communication. The switches only followed the instructions of the CCP and actually made the connections that furthered the communications path. In one embodiment, the switches were allowed to select the actual connections used, but even these selections were based on CCP selections.

As illustrated above, the CCP allows a telecommunications network to separate communication control from the communications path. In prior systems, the switches would select the network elements and the connections, as well as, actually providing a part of the actual connection. As a result, prior systems are restricted to the communication control capabilities provided by the switches. Prior systems have used remote devices, such as an SCP, to support switch control, but the remote device only answered queries in response to the switches processing of the signal. These remote devices do not process the signaling before the switch had already applied the signaling. By using the CCP, telecommunications systems can control communications independently of the capability of the switches to accomplish both tasks.

FIG. **2** shows a block diagram of another embodiment of the present invention. CCP **250** and network **210** are shown. CCP **250** is communications control processor CCP **250** could be integrated into network **210**, but need not be and is shown separately for clarity. Network **210** could be any type of telecommunications network that operates using network elements, signaling, and connections. Examples would be LECs, IXCs, LANs, MANs, WANs, and Cellular Networks, but there are others. Additionally, network **210** could be narrowband, broadband, packet-based, or a hybrid. Network **210** is capable of providing communications paths between points both inside and outside of network **210**. CCP **250** and network **210** are linked by link **214** and are able to signal each other in order to establish these paths.

Additionally, user **220** and user **230** are shown and are also capable of signaling. Examples of users **220** and **230** might be telephones, computers, or even switches in another telecommunications network. Users **220** and **230** are connected to network **210** by connections **222** and **232** respectively. Users **220** and **230** are linked to CCP **250** by links **224** and **234** respectively. Signaling may be transmitted over links **224** and **234**. If in-band signaling is employed on connections **222** and **232**, network **210** would separate at least a portion of the signaling out-of-band and transmit it to CCP **250** over link **214**.

Also shown are various network elements. As with CCP **250**, these elements could also be integrated into network **210**, but are shown separately for clarity. These network elements are: networks **260**, operator centers **262**, enhanced platforms **264**, video servers **266**, voice servers **268**, and adjunct processors **270**. This is not an exclusive list. Those skilled in the art will recognize these network elements and their functions, as well as the many other types of telecommunications devices, such as billing servers, that are applicable in this situation.

Each network element is connected to network **210** by connection **212**. Connection **212** represents several actual connections between the network elements (**260**-**270**) and different elements in network **210**. One bus-type connection is shown for purposes of clarity, but those skilled in the art are familiar with many actual types of connections to use. Additionally link **256** is shown from CCP **250** to the network elements (**260**-**270**). Link **256** is similarly represented as a bus-type link for clarity, and multiple links are actually used,

although some network elements may not even require links. Link **214** has been simplified for clarity in the same fashion.

In one embodiment, user **220** may desire to establish a communications path to user **230**. CCP **250** would make the appropriate selections and signal the network elements in network **210** as discussed with regard to the embodiments of FIG. **1**. As a result, a communications path would be established from user **220** to user **230** through network **210** and connections **222** and **232**.

In another embodiment, user **220** may desire to access one of the various network elements (**260-270**). User **220** will typically seize connection **222** to network **210** and generate signaling. Both in-band signaling on connection **222** and out-of-band signaling on link **224** would be directed to CCP **250**. By processing the signaling, CCP **250** can select any of the network elements (**260-270**) and control the communications through network **210** and connection **212** to the network elements (**260-270**).

For example, should user **220** desire to connect to a video server and another network, user **220** would signal the request. The signaling would be directed to CCP **250** over link **224**, or over connection **222** and link **214** as discussed above. CCP **250** would process the signaling and make the appropriate selections. CCP **250** would signal network **210** and video servers **266** of its selections. As a result, a communications path would be set-up from user **220** to video servers **266**.

Additionally, CCP **250** would control communications to the other network which is represented by networks **260**. Networks **260** could be any other form of telecommunications network—either public or private. CCP **250** would make the appropriate selections to further the communications path over connection **212** and network **210** to networks **260**. Upon signaling from CCP **250**, the connections comprising the communications path would be made. Networks **260** would also be signalled by CCP **250** over link **256**. As such a communication path is set up from user **230** to video servers **266** and on to networks **260**.

There may also be several devices represented by particular network element shown on FIG. **2**. CCP **250** could also select the particular device to access. For example, take the situation in which voice servers **268** represents **20** individual voice server devices split among three different locations. On each call, CCP **250** could select the actual voice server device which should be used on that call and control the communications through network **210** and connection **212** to the selected device. Alternatively, CCP **250** may only be required to select group of devices, for instance at a particular location, instead of the actual device.

As is known, large telecommunication networks are comprised of numerous network elements, connections, and links. The present invention is suitable for use in this context. FIG. **3** shows a version of the present invention in the context of a large network. Typically, this network would be comprised of several broadband switches, narrowband switches, muxes, signal transfer points (STPs), Service Control Points (SCPs), operator centers, video servers, voice servers, adjunct processors, enhanced services platforms, connections, and links. For purposes of clarity, only a few of these possibilities are shown on FIG. **3**. For the same reason, connections and links are not numbered.

FIG. **3** shows Telecommunications Network **310** which is comprised of STP **340**, STP **345**, CCP **350**, SCP **355**, broadband switches **360**, **362**, **364**, and **366**, interworking units **361** and **365**, narrowband switches **370** and **375**, and muxes **380**, **382**, **384**, and **386**. Aside from CCP **350**, these elements of a large network are familiar to one skilled in the art and examples of the of these network elements are as follows: STP—DSC Communications Megahub; SCP—Tandem CLX; broadband switch—Fore Systems ASX-100; narrowband switch—Northern Telecom DMS-250; and mux—Digital Link PremisWay with CBR module.

In at least one embodiment, the broadband switches are equipped with signaling interworking units. These units translate SS7 messages into B-ISDN messages. In that event, the CCP could transmit SS7 to the broadband switches which could convert the signals, properly. Interworking is discussed in ITU-TS Recommendation Q.2660, "B-ISDN, B-ISUP to N-ISUP Interworking."

When user information passes from a broadband network to a narrowband network, it typically must pass through a mux. Muxes can convert transmitted information back and forth between narrowband and broadband formats. In at least one embodiment, each broadband connection on one side of a mux corresponds to a narrowband connection on the other side of the mux. In this way, the CCP can track connections through the mux. If the communication path is on a given narrowband connection entering the mux, it will exit the mux on its corresponding broadband connection. This correspondence allows the CCP to identify connections on each side of the mux based on the entry connection. Muxes are typically placed at any interface between narrowband and broadband connections.

As long as the connections correspond through the mux, the CCP can track the communication path properly. Alternatively, the connections may not correspond. In that case, signaling links between the muxes and the CCP would be required for the devices to communicate and allow the CCP to track the communication path.

Additionally, Telecommunications Network **310** includes the connections and links which are not numbered. These connections and links are familiar to those skilled in the art. Some examples of possible connections are switched digital lines, satellite links, microwave links, cellular links, and dedicated digital lines, but there are others. The signaling links are typically data links, such as 56.kilobit lines. The signaling may employ SS7. Broadband, C6, C7, CCIS, Q.933, Q.931, T1.607, Q.2931, B-ISUP or other forms of signaling technology. The present invention is fully operational with the many variations which are well known in the art. Additionally, it is also known that a direct link between two devices can be used instead of an STP for signal routing.

Outside of Telecommunications Network **310** are first point **320**, second point **330**, LEC switch **325**, LEC switch **335**, LEC STP **328**, and LEC STP **338**. These devices are shown along with their links and connections. First point **320** is connected to LEC switch **325**. LEC switch **325** is linked to LEC STP **328** which mutes signaling from LEC switch **325**. LEC switch **325** is also connected to mux **380** of Telecommunications Network **310**. LEC STP **228** is linked to STP **340** of Telecommunications Network **310**.

STP **340** is linked to STP **345**. The other links are as follows. STPs **340** and **345** are linked to CCP **350**. CCP **350** is linked to interworking units **361** and **365** of broadband switches **360** and **364** respectively. CCP **350** is linked to broadband switches **362** and **366**, and narrowband switch **375**. STP **345** is linked to narrowband switch **370** and SCP **355**. STP **345** is also linked to LEC STP **338** which is linked to LEC switch **335**.

Mux **380** is connected to broadband switch **360**. Broadband switch **360** is connected to broadband switches **362** and **364**. Broadband switch **362** is connected to mux **384** which is connected to narrowband switch **375**. Broadband switch **364** is connected to mux **382** which is connected to narrowband switch **370**. Broadband switches **362** and **364** are both con-

nected to broadband switch **366**. Broadband switch **366** is connected to mux **386** which is connected to LEC switch **335**. LEC switch **335** is connected to second point **330**.

When a call is placed from first point **320** that requires the use of Telecommunications Network **310**, LEC switch **325** will typically seize a connection to Telecommunications Network **310** and generate a signal containing call information. At present, this signal is in SS7 format and the seized connection is a DS0 port. The signal is transmitted to LEC STP **328** which transfers it on to STP **340**. LEC switch **325** also extends the communication path over the seized connection. These LEC components and the process of establishing communication paths between a point, a LEC, and an IXC are familiar to those skilled in the art.

Telecommunications Network **310** accepts the communication path on the narrowband side of mux **380**. The present invention can also accept broadband calls that do not require a mux, but typically, calls from a LEC will be narrowband. Mux **380** converts the call to broadband and places it on the broadband connection that corresponds to the seized connection. The communication path extends to broadband switch **360** through mux **380**.

STP **340** transfers the signal from LEC STP **328** to STP **345** which, in turn, routes the signal to CCP **350**. Also, CCP **350** accepts status messages from the broadband and narrowband switches over standard communications lines, and may query SCP **355** for information. Any suitable database or processor could be used to support CCP **350** queries. CCP **350** uses this information and its own programmed instructions to make communication control selections. For calls that require narrowband switch treatment, CCP **350** will select the narrowband switch.

Preferably, CCP **350** can select any narrowband switch in Telecommunications Network **310**. For example, it may extend the communication path through the broadband network to a narrowband switch across the network for processing, or it may extend the communication path to a narrowband switch connected to the broadband switch that originally accepts the communication path. Additionally, no narrowband switch may be required at all. For clarity, all of the switches representing these possibilities are not shown on FIG. **3**.

CCP **350** will select at least one network characteristic in response to the signaling. Typically, this will be the network elements or connections that will make the communication path. As discussed with regard to the above embodiments, CCP **350** may select only the network elements and allow the switches to select the connections, or the selections can be distributed among the two. For example, CCP **350** may only select some of the network elements and connections and allow the switches to select some of the network elements and connections. CCP **350** might only select the narrowband switches and allow the broadband switches to select the broadband switches that will make the communication path. CCP **350** can also select other network characteristics, such as applications and control instructions.

In one embodiment, CCP **350** will select the narrowband switches to process particular calls and the DS0 ports on those switches which will accept these calls. The broadband switches will select the broadband switches and the broadband connections to the DS0 port. Restricted to the possibilities depicted on FIG. **3**, CCP **350** may select either narrowband switch **370** or narrowband switch **375** to process the call. Assuming CCP **350** selects narrowband switch **370**, it would also select a DS0 port on narrowband switch **370** to accept the connection. CCP **350** would then signal broadband switch **360** through interworking unit **361** to further the communications path to the selected DS0 port on narrowband switch **370**.

Of the possible routes, broadband switch **360** would be left to select the other broadband switches and connections to use. Assuming the route directly to broadband switch **364** is selected, broadband switch **360** would further the communications path to that switch. Broadband switch **360** would also signal broadband switch **364** of the communication path. Broadband switch **364** would farther the communication path to through mux **382** to access the specified DS0 port on narrowband switch **370**. This is accomplished by corresponding the connections through the mux as discussed above. CCP **350** will signal narrowband switch **370** of the incoming communication path. This signal is routed by STP **345**. Narrowband switch **370** will process the call on the specified DS0 port. Typically, this would include billing and routing the call. Narrowband switch **370** may also query SCP **355** to aid in application of services to the call. For example, narrowband switch **370** may retrieve an "800" translation from SCP **355**. As a result of the processing, narrowband switch **370** will switch the call and generate a new signal which may include routing information. The signal is sent to CCP **350** through STP **345**. The communication path is furthered on a new connection back to broadband switch **364** through mux **382**. CCP **350** may use the information in the signal, SCP information, network element information, operational instructions, and/or its own routing logic to make new selections for the call. The network element information and operational instructions could be signalled to CCP **350** or delivered over standard data lines.

In one embodiment, the selection of a network characteristic will include the selection of a network code. Network codes are the logical addresses of network elements. One such code is a destination code that facilitates egress from Telecommunications System **310**. The destination code typically represents a network element that is connected to a LEC switch. Once a destination is selected, CCP **350** will signal broadband switch **364** of its selections and the communication path will be furthered through the broadband network accordingly. In the current example this could be through broadband switch **366** and mux **386**. The communication path would be furthered to the specified port on LEC switch **335**. Typically, this involves the seizure of a connection on the LEC switch by the IXC.

In one embodiment, whenever broadband switch **366** extends a communication path to mux **386**, it is programmed to signal CCP **350** of the broadband connection it has selected. This allows CCP **350** to track the specific DS0 port on the LEC switch that has been seized. CCP **350** would signal LEC switch **335** through STP **345** and LEC STP **338** of the incoming call on the seized DS0 connection. As a result, LEC switch **335** would further the communication path to second point **330**.

It can be seen from the above disclosure that the present invention allows a telecommunications network to employ a broadband network to make call connections. By using muxes to convert calls and a CCP to analyze signaling, this broadband network remains transparent to the networks of other companies. An example of such a transparent interface is between an interexchange carrier (IXC) network and a local exchange carrier (LEC) network. Similarly the network will be transparent if deployed in only a portion of a single company's network infrastructure.

In the above embodiment, the LEC seizes an IXC DS0 port and signals to an IXC STP. The mux and the CCP convert the

call and analyze the signal appropriately. No changes in other existing carrier systems, such as LEC systems, are required.

Additionally the narrowband switch receives the call and signal in its own format and switches the call. Although the switch may "think" the call is routed over a trunk to another narrowband switch, the call actually goes right back to the mux and broadband switch that sent the call. The narrowband switch is used to apply features to the call, i.e. billing, routing, etc. The broadband network is used to make the substantial portion of the call connection. The CCP may use narrowband switch call processing information to make selections.

The CCP performs many functions. In one embodiment, it accepts signaling from a first point or LEC and provides appropriate signals in accord with the communication control selections it has made. These selections are network characteristics. The CCP may select network elements such as switches, servers, or network codes. The CCP may select connections, such as DS0 circuits and ports. The CCP may select particular telecommunications applications to be applied to the communications path. The CCP may select particular control instructions for particular devices. The CCP may also receive information from entities such as SCPs, operational control, or switches to aid in its selections.

The CCP is a processing system, and as such, those skilled in the art are aware that such systems can be housed in a single device or distributed among several devices. Additionally, multiple devices with overlapping capabilities might be desired for purposes of redundancy. The present invention encompasses these variations. One such operational system would be multiple pairs of CCPs located regionally within a telecommunications system. Each machine would be equally capable of communication control. One example of a CCP device would be a Tandem CLX machine configured in accord with this disclosure of the present invention.

A signaling point handles the signaling for a switch. Switches which are used to route calls typically have a signaling point which is directly coupled to a processor in the switch. This processor controls a switching matrix in the switch in response to the signaling processed by the signaling point. Thus, there is typically a one to one correspondence of a signaling point for each switch and matrix.

The CCP is not directly coupled to one switch, one switch processor (CPU), or one switching matrix. In contrast, the CCP has the capability of directing a plurality of switches. Thus, the CCP can direct multiple switch matrixes by signaling multiple signaling points.

It is possible to house the CCP within other telecommunication devices, even switches. Although the CCP can be primarily distinguished from a switch CPU based on physical location, this does not have to be the case. A switch CPU receives information from a signaling point and controls the matrix of a single switch. Some switches distribute the matrix among different physical locations, but the CPU controls each matrix based on information received from a single signaling point. This information is not signaling.

In contrast, the CCP receives signaling and has the ability to signal other network elements. It can communicate with multiple signaling points. These signaling points provide information to the switch CPUs which control the switch matrixes. By signaling multiple signaling points, the CCP is able to direct the matrixes of multiple switches based on the signaling and other information the CCP obtains. A CCP is not associated with a single switch matrix. A CCP does not require communication path connections in order to operate.

The main capabilities of one version of a CCP are shown on FIG. **4**. CCP **450** comprises interface **460**, translator **470** operably connected to interface **460**, processor **480** operably connected to translator **470**, and memory **490** operably connected to processor **480**.

CCP **450** functions to physically connect incoming links from other devices such as STPs, switches, SCPs, and operational control systems. Interface **460** is functional to accept the signals off of these links and transfer the signals to translator **470**. Interface **460** is also be able to transfer signaling from translator **470** to the links for transmission.

Translator **470** accepts the signaling from interface **460** and identifies the information in the signaling. Often, this will be done by identifying a known field within a given signaling message. For example, translator **470** might identify the Origination Point Code (OPC), Destination Point Code (DPC), and Circuit Identification Code (CIC) in an SS7 message. Additionally, translator **470** must be able to formulate outgoing signaling and transmit it to interface **460** for transmission. For example, translator **470** might replace the OPC, DPC, and CIC in a given SS7 message and transfer the modified SS7 message to interface **460** for transmission. Translator **510** must be equipped to manage the signaling formats it will encounter. Examples are SS7 and C7.

Processor **480** accepts the signaling information from translator **470** and makes the selections that accomplish communication control. This includes the selection of the network elements and/or connections that make the communications path. Typically, selections are made through table look-ups and SCP queries. Tables are entered and queries are generated based in part on the information identified by translator **470**. The table look-ups and SCP information retrieval yield new signaling information. The new information is transferred to translator **470** for formulation into appropriate signals for transmission. Algorithm solution could also be used to make selections. Processor **480** also handles, various status messages and alarms from the switches and other network elements. Operational control can also be accepted. This information can be used to modify the look-up tables or selection algorithms. Memory **490** is used by processor **480** to store programming, information, and tables.

FIG. **5** shows a flow diagram for the CCP for a version of the present invention. The sequence begins with the CCP receiving different types of information. Box **500** depicts the CCP accepting a signal from a first point. This signal could be in any format, such as SS7 or broadband signaling. The signal may have passed through STPs from a LEC over a signaling link, or it may also be a signal directly provided by an individual user of a network. The signal contains information about the requested communication path. An example of such information is the message type which indicates the purpose of the message. Another example of such information is set-up information such as transit network service value, bearer capability, nature of address, calling party category, address presentation restriction status, carrier selection value, charge number, and originating line information, and service code value. Other information might be a network indicator or a service indicator. Those skilled in the art are familiar with these types of information.

Other types of information might also be accessed by the CCP. The network elements, such as switches, may provide the CCP with information as shown in box **505**. This information allows the CCP to select network elements and connections based on network conditions. Examples of possible types of such information could be management messages, loading, error conditions, alarms, or idle circuits. The CCP might also provide the network elements with information.

Box **510** shows that operational control might be provided. Operational control allows system personnel to program the

CCP. An example of such control might be to implement a management decision to retire a particular network element. Operational control would allow the removal that element from the selection process.

The CCP processes the information is has received in box **515**. Processing also entails the use of programmed instructions in the CCP, and might even include the use of information retrieved from a remote database, such as an SCP. The selections are then made as shown in box **520**. These selections specify network characteristics, such as network elements and/or connections. As stated above, The CCP may only select a portion of the network characteristics and allow the points or the switches to select the remainder. It should be pointed out, that the information used in processing is not limited to that which is listed, and those skilled in the art will recognize other useful information which may be sent to the CCP.

Once network characteristics are selected, the CCP will signal the points and the applicable network elements of the selections. In box **525**, signals are formulated instructing the network elements of the network characteristics selected. The signals are transmitted to the appropriate network elements in box **535** which will typically result in a communication path through the network elements and connections. Other activity, such as applications and control procedures might be implemented as well. Additionally, in boxes **530** and **540**, signals are formulated and sent to the points. Typically the new signals generated by the CCP are sent to network elements or multiple signaling points. These new signals could be the same, however different signaling is typically sent to the different network elements which may used as part of a communication path.

FIG. **5** represents the sequence that the CCP performs in one embodiment to control communications and establish a communication path from a first point to a second point through network elements and connections. FIGS. **6** and **7** represent a similar sequence, and they are in the context of an Interexchange Carrier (IXC) similar to that depicted in FIG. **3**. The IXC accepts DS0 connections and SS7 signaling from a LEC and employs a broadband system to make the substantial portion of the communication path.

FIG. **6** depicts the flow of the CCP in a version of the present invention when a communication path is established from the LEC to a narrowband switch in the IXC. Box **600** shows that an SS7 message is accepted from the LEC which contains a Message Transfer Part (MTP) and an Integrated Service User Part (ISUP). As those skilled in the art are aware, the MTP contains the Originating Point Code (OPC) and the Destination Point Code (DPC). These point codes define specific signaling points in the network and are typically associated with a switch. As such, the OPC and DPC define a portion of the desired communication path.

When the communication path is extended into the IXC network, the OPC designates the LEC switch that connected to the IXC (#**325** on FIG. **3**). Previously, the DPC has designated the narrowband switch that the LEC would connect to for calls into the IXC. In this embodiment of the present invention, the DPC may designate a particular narrowband switch from the LEC's perspective, but the CCP actually selects the actual narrowband switch used. A mux or a broadband switch accepts the connection from the LEC, not a narrowband switch.

The ISUP contains the Circuit Identification Code (CIC) which designates the DS0 port that the LEC has seized. Previously, this DS0 Port was on a narrowband switch, but in this embodiment of the present invention, the DS0 port is actually on a mux.

Box **605** shows that the CCP may receive status information from the narrowband switches. These messages include Operational Measurements (OM) and CPU Occupancy information. OM includes trunk usage status of the switches which tells the CCP which DS0 ports are available on the narrowband switches. CPU Occupancy tells the CCP of the specific switching load of each narrowband switch. Box **610** shows that the CCP may also accept status information from the broadband switches indicating which connections are idle. This information allows the CCP to specify and balance routing through the broadband switches if desired. As discussed in relation to some of the other embodiments, the broadband switches may be left with that selection.

The CCP processes the information it has received in box **615**. Those skilled in the art are aware of other information which would be useful in this context. As a result of the processing, a narrowband switch and a DS0 port on that switch are typically selected as shown in box **620**. The selected narrowband switch may be close to the LEC or across the broadband network. The CCP determines which narrowband switch will process the call. This makes the narrowband switches virtually interchangeable.

Box **625** shows that a signal indicating these selections is generated and sent to the appropriate broadband switches in box **635**. As discussed, the broadband switches may employ interworking units to handle signaling. Typically, the broadband switches will use internal tables to select broadband connections based on information in the signal from the CCP. Such information might identify the existing extent of the communication path and specify the narrowband switch and the DS0 port on that switch to which the communication path should be extended. The tables would be entered with this information and yield a particular broadband connection to use. Broadband switches further along the communications path could also receive similar signals from the CCP and use similar tables. Alternatively, the broadband switches further along the communications path might only need to enter an internal table using the incoming broadband connection and yield a new broadband connection on which to extend the communications path.

Those skilled in the art are familiar with broadband systems which can accomplish this. Broadband signaling is discussed in the following ITU-TS Recommendations: Q.2762 "B-ISDN, B-ISDN User Part—General Functions of Messages"; Q.2763 "B-ISDN, B-ISDN User Part—Formats and Codes"; Q.2764 "B-ISDN, B-ISDN User Part—Basic Call Procedures"; Q.2730 "B-ISDN, B-ISDN User Part—Supplementary Services"; Q.2750 "B-ISDN, B-ISDN User Part to DSS2 Interworking Procedures;" and Q.2610 "Usage of Cause and Location in B-ISDN User Part and DSS2."

In at least one embodiment, the broadband switches are equipped with signaling interworking units. These units translate SS7 messages into B-ISDN messages. In that event, the CCP could transmit SS7 to the broadband switches which could convert the signals properly. Interworking is discussed in ITU-TS Recommendation Q.2660, "B-ISDN, B-ISUP to N-ISUP Interworking."

In one embodiment, the broadband switches may select the actual virtual connection that corresponds through a mux to a DS0 port. This DS0 port could be on a narrowband switch or a on a point, such as a LEC switch. In this case, the CCP would not need to select a DS0 port since the broadband switch was in effect doing so. The internal tables of the broadband switches would be programmed to trigger when the particular broadband switch was connecting to particular broadband connections. These connections might be to a DS0 port on a narrowband switch or any specified point. Upon the trigger,

the broadband switch would signal the CCP of the broadband connection it has used. The CCP would incorporate this information into the signal it sends to the narrowband switch or specified point. It is preferred that the CCP select the DS0 port on the selected narrowband switches, and that the broadband switches be allowed to select the broadband connection out of the network (through a mux) and signal the CCP of its selection.

The SS7 message from the LEC informed the CCP which DS0 port had been seized (the CIC), on which IXC device (DPC), and by which LEC switch (the OPC). By tracking the DS0 Port through the mux (#**380** on FIG. **3**), the .CCP knows which connection the communication path will use to get to the broadband switch (#**360** on FIG. **3**). The CCP provides the broadband network with the proper signaling to extend the communication path from this switch to the selected narrowband switch as shown in box **635**.

Box **630** shows that the CCP formulates an SS7 message based on the selections relating to the narrowband switch. SS7 message formulation methods, such as drop and insert, are known in the art. A new DPC is inserted that will designate the narrowband switch selected by the CCP. A new CIC is inserted that will designate the DS0 port on that switch as selected by the CCP. The SS7 message is sent to the narrowband switch in box **640**.

As such, the communication path is extended from the LEC through the broadband network to the narrowband switch, and the narrowband switch is notified of the incoming communication path. Another portion of the SS7 message contains call information including ANI and DNIS. This information was supplied by the LEC and is in the SS7 message sent to the narrowband switch.

The narrowband switch uses this information along with its own programming to switch the call. This switching may include various switching programs and remote databases. The narrowband switch will select a new DPC based on this processing. It will switch the call to a new DS0 port. Previously, this port was connected to a trunk connected to the next narrowband switch in the call routing scenario. However, in the present invention, the DS0 port is connected through a mux to broadband switch. The narrowband switch will place the new DPC in an SS7 message. Along with the new DPC, a new CIC identifying the, new DS0 circuit, and a new OPC designating the narrowband switch itself is placed in the SS7 message and sent to the CCP.

FIG. **7** shows the flow of the CCP when extending a communication path from the selected narrowband switch to a point outside of the IXC in one embodiment of the present invention. The SS7 message generated by the narrowband switch after processing the call is received by the CCP in box **700**. In it, the CIC designates the DS0 port the communications path extends from on the narrowband switch. Because this port is connected to a mux with corresponding connections, the CCP can determine which connection the communication path uses to extend back to the broadband switch.

The CCP may also receive status information from the broadband switches as shown in box **705**. This information allows the CCP to select broadband connections if desired. As discussed, the broadband switches may make these selections. Typically, the broadband switches will use internal tables to select broadband connections based on information in the signal from the CCP. Such information might specify, destination code. The destination code might correspond to a terminating switch or a LEC switch to which the communication path should be extended.

As shown in box **710**, the CCP applies processing and selects the appropriate destination for the broadband network to extend the communication path to as shown in box **715**. The CCP may use the new DPC provided by the narrowband switch to identify the destination for the broadband communication path.

In box **720**, signals are generated reflecting this selection and sent to the appropriate broadband switches in box **725**. As discussed, the broadband switch may trigger and signal the CCP when it uses particular connections. This would occur for a connection through a mux to a LEC switch. This signal is accepted by the CCP in box **730** and is used to identify the DS0 port. An SS7 message is formulated in box **735** and in it the CIC will identify this DS0 connection on the LEC switch (#**335** on FIG. **3**). Alternatively, this DS0 port may have been selected by the CCP and signalled to the broadband switch. The LEC is signalled in box **740**.

From FIGS. **6** and **7**, a sequence is shown that demonstrates the procedures that the CCP can follow to accept signaling from the LEC and make selections that control communications through the IXC network. The CCP must produce signals to implement its selections and transmit them to the applicable network elements. The CCP is able to use the routing, billing, and service features of a narrowband switch, but is still is able to employ a broadband network to make a substantial part of the communications path.

FIG. **8** is a flow diagram of CCP signal processing in one embodiment of the invention. Box **800** shows that an SS7 signal has been accepted by the CCP. Box **805** shows that the CCP determines the message type. If the message is not a call message, it is routed or used to update the CCP memory if appropriate as shown in box **810**. Non-call messages are familiar to those skilled in the art with examples being filler or management messages. If the SS7 message is a call message, it is examined to determine if it is an initial address message (IAM) in box **815**. Call messages and IAMs are familiar to those skilled in the art. If it is an IAM, the information provided by automatic number identification (ANI) is used to validate the call in box **820**. ANI validation is accomplished with a table look-up and is well known. If invalid, the communication path is terminated as shown in box **825**.

Once an IAM with a valid ANI is determined, a table is entered, which yields an OPC—DPC—CIC combination as shown in box **830**. One skilled in the art will recognize that such a table can take many forms. One example is to set up a table with every combination of OPC—DPC—CIC on one side. The table is entered using the OPC—DPC—CIC of the incoming IAM message. After entry through these fields is accomplished, the table yields a new OPC—DPC—CIC which can be formulated into the SS7 message and sent to the switching network as shown in box **835**. The switching network is capable of using this information to make connections.

Once the IAM signal has been processed, subsequent SS7 messaging can be processed by a separate CIC look-up table entered using the CIC as shown in box **840**. Subsequent messages, such as address complete, answer, release, and release complete can be processed by entering the CIC table using the CIC in these non-IAM signals. For signals directed to the first point, the table yields the original OPC which is used as the DPC. Additionally, subsequent messages from the first point enter the CIC table using their CIC, and the table yields the DPC previously selected by the CCP for the IAM processing. The CIC table is constantly updated to reflect current processing as shown in box **845**. In this way, the CCP is able to efficiently process non-IAMs because these signals only need to reflect the results of previous IAM selections.

There can be exceptions to the use of the CIC table for non-IAM call messages. One example would be if a new

connection is allowed after release. In that case, the IAM procedures would be followed.

Those skilled in the art will recognize the numerous factors that can be used to design and load the tables. Different OPC—DPC—CIC combinations can be yielded by the tables based on many factors. Some of these factors are: called number, time of day, CPU occupancy, switch status, trunk status, automatic call distribution, operational control, error conditions, network alarms, user requests, and network element status.

For example, if a certain switch must be taken out of service, it is merely replaced in the table with suitable substitutes. The switch is then effectively taken out of service because it is no longer selected. If the CPU loading of a certain switch reaches a threshold, its presence in the tables can be diminished and distributed to other switches.

In another example, if it is busy hour in region A, the tables may yield network elements in region B to process the call. This can be accomplished by adding an area code or a dialed number entry, and time of day entry in the table. For calls placed from an OPC in region A to an area code or dialed number in region B, a narrowband switch in region B could be selected. As such, the DPC yielded by the table during this time frame should reflect a region B narrowband switch. Also, for calls placed from an OPC in region B to an area code or dialed number in region A, the tables should provide the DPC of a region B narrowband switch.

In a preferred embodiment, IAM messages would cause the CCP to query an SCP, data element, or database for support. The SCP would answer the query by using tables as discussed above. The answers would sent to the CCP and used to formulate signaling. Subsequent messages would be then handled by the CCP using the CIC table. An example of such support would be for the CCP to query the SCP in response to receiving an IAM message. The query may include the OPC, CIC, DPC, and the area code, or dialed number. The SCP could use this information to select network characteristics and avoid busy regions as described in the above busy region example. For example, the SCP would maintain tables for OPC—dialed area code—time of day combinations that would yield a new DPC and CIC. This assumes that busy hour in a region corresponds to time of day, but other factors and yields could also be involved.

In one embodiment, the dialed number or area code could he used to select the new DPC, and time stamps could be placed in the signaling. This might entail tables with OPC—dialed area code entries that yield a new DPC and CIC. In this case, narrowband switches may not even be needed since billing can be applied using the time stamps. The CCP could then route the call directly using only the broadband network. This is especially relevant for POTS calls in which only an area code entry would need to be added to the tables.

As discussed above, often a connection will consist of two separate connection procedures. One connection procedure will be from the origination to a selected network element. The other connection procedure will be from the selected network element to the destination. Also it has been disclosed that the CCP could actually be discreet machines located regionally. In these cases, the CCP device processing the first connection procedure could be located in the origination region, and the CCP device that processes the second connection procedure could be located in the region of the selected network element.

The present invention offers the advantage of separating at least a portion of the communication control from the communication path. By examining and translating signaling independently of the communication path, multiple switches and network elements can be connected in the optimum way. Communications paths are no longer limited to only the connections the switches can control. Networks do not have to wait for standardization among signaling and interface protocols.

The present invention allows for the selection of network characteristics, such as network elements and connections, before switches process or apply the signaling. The switches are not required to have a capability either to make selections or to signal each other. The switches only make connections as directed by the CCP which signals in each switches own signaling format. Various criteria can be used for the selections in the CCP, such as time of day, load balancing, or invalid ANI. As such, the present invention allows for a smooth transition from narrowband to broadband networks. It also allows for the selection of network elements, such as servers and enhanced services platforms.

The present invention represents a fundamental and powerful departure from previous telecommunications technology. By separating the communications path from communication control, the CCP can utilize different networks and network devices intelligently. Previously, telecommunications systems have been dependent on the switches to accomplish communication control. As such, telecommunications systems have had to wait for the switches to develop communication control before new technology could be implemented. Switches have always been required to physically make connections and provide control over which connections are required. Switch capabilities have not been able to keep up with all of the network possibilities available. The result is a limited system.

Switches have been given support in this dual task. SCPs, STPs, and adjunct processors provide support for communication control. However, these devices only support the switches communication control, and the switch remains essential to communication control. This dependence has created a bottleneck given the available network possibilities.

One advantage of the present invention is that it allows narrowband switches be used interchangeably in a narrowband/broadband hybrid network. Any narrowband switch may be taken out of service without re-routing traffic and changing routing logic in each switch. The CCP is simply programmed not to select the given narrowband switch for call processing. The CCP will route calls over the broadband network to another narrowband switch. This flexibility also allows the telecommunications network to easily transfer narrowband switch loads.

An important advantage of this system is that both the advantages of broadband and narrowband systems are utilized. The transmission capabilities of a broadband network are coupled with the narrowband network's ability to apply features. For example, the CCP can use the broadband network to substantially make the call connection from origination to destination. The CCP diverts the traffic to the narrowband network for processing. The narrowband network can apply features, such as billing and routing. Once processed, the traffic is directed back to the broadband network for completion of the connection. The CCP can then use the routing information generated by the narrowband system to route the traffic through the broadband system to the destination. As a result, the telecommunications system does not have to develop a billing or "800" routing feature for its broadband network. This can be accomplished because the CCP allows both networks to work together intelligently.

Another advantage of the present invention is the elimination of a substantial percentage of the DS0 ports required on the existing narrowband switches. In the current, architec-

tures, narrowband switches are interconnected to each other. A substantial percentage of the switch ports are taken up by these connections. By eliminating the need for the switches to connect to each other, these ports can be eliminated. Each narrowband switch is only connected to the broadband system. This architecture requires fewer ports per switch. By load balancing with the CCP, the number of ports required on busy switches can be reduced. The architecture in the present invention does require additional broadband ports, but these can be added at a significant cost saving versus narrowband ports.

Additionally, the narrowband switches no longer signal each other since all signaling is directed to the CCP. This concentration accounts for a reduction in required signaling link ports. This reduction possibly could result in the elimination of STPs.

As mentioned above, an advantage of the present invention is its ability to treat narrowband switches, or groups of narrowband switches, interchangeably. The CCP can pick any narrowband switch to process a particular call. This allows the network to pull narrowband switches out of service without taking extreme measures. In turn, this simplifies the introduction of new services into the network. A switch can be pulled out of service simply by instructing the CCP to stop selecting it. The switch can be re-programmed and put back into service. Then the next switch can then be updated in the same manner until all of the switches are implementing the new service. Switches can also be easily pulled to test developing applications.

This narrowband switch flexibility also allows the CCP to balance switch loads through the network during peak times, or during mass calling events. This eliminates the need to implement complex and expensive load balancing features in the narrowband network. Instead of programming the several switches to balance among themselves, one command to the CCP can achieve this.

Another advantage is the reduction in call set-up time. Most large networks require that a call pass through more than two narrowband switches arranged in a hierarchical fashion. One large network employs a flat architecture in which all narrowband switches are interconnected, but this still requires that the call pass through two narrowband switches. In the present invention, only one narrowband switch is required for each call. The use of broadband switches to set-up and complete the call represents significant time savings.

What is claimed:

1. A method of operating a telecommunication system, the method comprising:

receiving first signaling from customer premises equipment into a communication control processor;

processing the first signaling in the communication control processor to select an address of a network element;

transferring second signaling indicating the address from the communication control processor;

transferring third signaling from the communication control processor to a narrowband network;

receiving a voice communication from the customer premises equipment into a broadband network;

transferring the voice communication in the broadband network to the network element; and

transferring the voice communication from the network element to the narrowband network.

2. The method of claim **1** wherein the first signaling comprises broadband signaling.

3. The method of claim **1** wherein the second signaling comprises broadband signaling.

4. The method of claim **1** wherein the third signaling comprises Signaling System Seven (SS7) signaling.

5. The method of claim **1** wherein the third signaling comprises an Initial Address Message.

6. The method of claim **1** wherein transferring the voice communication in the broadband network to the network element comprises transferring the voice communication over connections, and further comprising in the broadband network, selecting the connections.

7. The method of claim **1** wherein the network element is connected to a local switch in the narrowband network and transferring the voice communication to the narrowband network comprises transferring the voice communication to the local switch.

8. A telecommunication system comprising:

a communication control processor configured to receive first signaling from customer premises equipment, process the first signaling to select an address of a network element, transfer second signaling indicating the address, and transfer third signaling to a narrowband network;

a broadband network configured to receive a voice communication from the customer premises equipment and transfer the voice communication to the network element; and

the network element is configured to receive the voice communication from the broadband network and transfer the voice communication to the narrowband network.

9. The telecommunication system of claim **8** wherein the first signaling comprises broadband signaling.

10. The telecommunication system of claim **8** wherein the second signaling comprises broadband signaling.

11. The telecommunication system of claim **8** wherein the third signaling comprises Signaling System Seven signaling.

12. The telecommunication system of claim **8** wherein the third signaling comprises an Initial Address Message.

13. The telecommunication system of claim **8** wherein the broadband network is configured to select connections and transfer the voice communication to the network element over the connections.

14. The telecommunication system of claim **8** wherein the network element is connected to a local switch in the narrowband network and is configured to transfer the voice communication to the local switch.

* * * * *

EXHIBIT K

US007327728B2

(12) **United States Patent**
Christie et al.

(10) **Patent No.: US 7,327,728 B2**
(45) **Date of Patent: *Feb. 5, 2008**

(54) **BROADBAND TELECOMMUNICATIONS SYSTEM**

(75) Inventors: **Joseph Michael Christie**, deceased, late of San Bruno, CA (US); by **Joseph S. Christie**, legal representative, Mt. Pleasant, PA (US); by **Jean M. Christie**, legal representative, Mt. Pleasant, PA (US); **Albert D. Duree**, Independence, MO (US); **Michael Joseph Gardner**, Prairie Village, KS (US); **William Lyle Wiley**, Atlanta, GA (US); **Manu Chand Bahl**, Hillsborough, CA (US); **Daniel Charles Sbisa**, Blue Springs, MO (US)

(73) Assignee: **Sprint Communications Company L.P.**, Overland Park, KS (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 479 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **10/629,265**

(22) Filed: **Jul. 29, 2003**
(Under 37 CFR 1.47)

(65) **Prior Publication Data**

US 2005/0147101 A1 Jul. 7, 2005

Related U.S. Application Data

(63) Continuation of application No. 09/497,719, filed on Feb. 4, 2000, now Pat. No. 6,631,133, which is a continuation of application No. 08/594,660, filed on Feb. 2, 1996, now Pat. No. 6,081,525, which is a continuation-in-part of application No. 08/525,897, filed on Sep. 8, 1995, now Pat. No. 5,991,301, which is a continuation-in-part of application No. 08/238, 605, filed on May 5, 1994.

(51) **Int. Cl.**

H04L 12/28	(2006.01)
H04L 12/56	(2006.01)
H04M 1/64	(2006.01)

(52) **U.S. Cl.** **370/389**; 370/410; 370/467; 379/88.17; 379/88.21

(58) **Field of Classification Search** 370/389, 370/410, 467; 379/88.17, 88.21
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,491,945 A 1/1985 Turner

(Continued)

FOREIGN PATENT DOCUMENTS

EP 0439098 7/1991

(Continued)

OTHER PUBLICATIONS

Kuribayashi, S-l, et al; Advanced Signaling Protocol for Broadband ISDN Services; Jan. 1, 1995: pp. 1-12; vol. 78; Electronics & Communications in Japan, Part 1—Communications, Scripta Technica; New York, US.

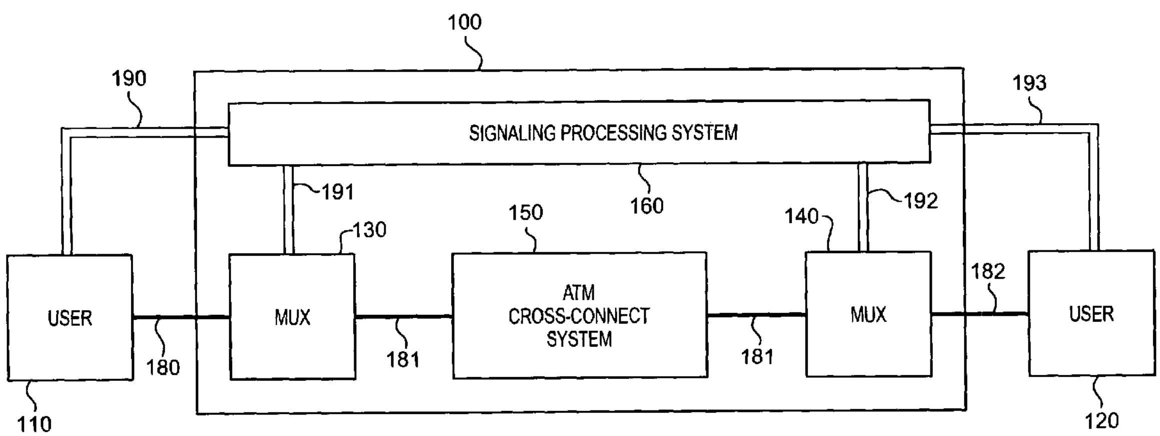
(Continued)

Primary Examiner—Alpus H. Hsu

(57) **ABSTRACT**

A communication system comprises a signaling processor configured to receive telecommunication signaling for calls, and responsively on a call-by-call basis, select routing information based on the telecommunication signaling and transfer control messages indicating the routing information. The communication system comprises a communication unit configured to receive the control messages and user communications for the calls, and responsively on the call-by-call basis, convert the user communications from a first communication format into a second communication format having headers that include the routing information selected by the signaling processor and transfer the user communications in the second communication format.

20 Claims, 16 Drawing Sheets



U.S. PATENT DOCUMENTS

4,683,584	A	7/1987	Chang et al.	
4,686,669	A	8/1987	Chang	
4,686,701	A	8/1987	Ahmad et al.	
4,720,850	A	1/1988	Oberlander et al.	
4,730,312	A	3/1988	Johnson et al.	
4,736,364	A	4/1988	Basso et al.	
4,748,658	A	5/1988	Gopal et al.	
4,757,526	A	7/1988	Foster et al.	
4,763,317	A	8/1988	Lehman et al.	
4,853,955	A	8/1989	Thorn et al.	
4,970,721	A *	11/1990	Aczel et al.	370/355
4,991,169	A	2/1991	Davis et al.	
4,991,172	A	2/1991	Cidon et al.	
5,003,584	A	3/1991	Benyacar et al.	
5,029,199	A	7/1991	Jones et al.	
5,048,081	A	9/1991	Gavaras et al.	
5,051,983	A	9/1991	Kammerl	
5,084,816	A	1/1992	Boese et al.	
5,089,954	A	2/1992	Rago	
5,115,426	A	5/1992	Spanke	
5,115,427	A	5/1992	Johnson, Jr. et al.	
5,185,743	A	2/1993	Murayama et al.	
5,204,857	A	4/1993	Obara	
5,251,255	A	10/1993	Epley	
5,258,979	A	11/1993	Oomuro et al.	
5,268,895	A	12/1993	Topper	
5,271,010	A	12/1993	Miyake et al.	
5,274,635	A	12/1993	Rahman et al.	
5,274,698	A	12/1993	Jang	
5,278,972	A *	1/1994	Baker et al.	709/246
5,282,244	A	1/1994	Fuller et al.	
5,289,472	A	2/1994	Cho	
5,291,492	A	3/1994	Andrews et al.	
5,297,147	A	3/1994	Shimokasa	
5,327,421	A	7/1994	Hiller et al.	
5,339,318	A	8/1994	Tanaka et al.	
5,345,443	A	9/1994	D'Ambrogio et al.	
5,345,445	A	9/1994	Hiller et al.	
5,345,446	A	9/1994	Hiller et al.	
5,363,433	A	11/1994	Isono	
5,375,124	A	12/1994	D'Ambrogio et al.	
5,377,186	A	12/1994	Wegner et al.	
5,392,402	A	2/1995	Robrock, II	
5,394,463	A	2/1995	Fischell et al.	
5,420,858	A	5/1995	Marshall et al.	
5,422,882	A	6/1995	Hiller et al.	
5,425,090	A	6/1995	Orriss	
5,428,609	A	6/1995	Eng et al.	
5,434,852	A	7/1995	La Porta et al.	
5,434,981	A	7/1995	Lenihan et al.	
5,438,527	A	8/1995	Feldbaumer et al.	
5,438,570	A	8/1995	Karras et al.	
5,440,563	A	8/1995	Isidoro et al.	
5,440,626	A	8/1995	Boyle et al.	
5,444,713	A	8/1995	Backaus et al.	
5,452,297	A	9/1995	Hiller et al.	
5,452,350	A	9/1995	Reynolds et al.	
5,457,684	A	10/1995	Bharucha et al.	
5,459,722	A	10/1995	Sherif	
5,469,501	A	11/1995	Otsuka	
5,473,677	A	12/1995	D'Amato et al.	
5,473,679	A	12/1995	La Porta et al.	
5,483,527	A	1/1996	Doshi et al.	
5,485,455	A	1/1996	Dobbins et al.	
5,495,484	A	2/1996	Self et al.	
5,506,894	A	4/1996	Billings et al.	
5,509,010	A	4/1996	La Porta et al.	
5,519,690	A	5/1996	Suzuka et al.	
5,519,707	A	5/1996	Subramanian et al.	
5,530,724	A	6/1996	Abrams et al.	
5,533,115	A	7/1996	Hollenbach et al.	
5,537,461	A	7/1996	Bridges et al.	
5,541,917	A	7/1996	Farris	
5,544,163	A	8/1996	Madonna	
5,550,834	A	8/1996	D'Ambrogio et al.	
5,550,914	A	8/1996	Clarke et al.	
5,563,939	A	10/1996	La Porta et al.	
5,566,173	A	10/1996	Steinbrecher	
5,568,475	A	10/1996	Doshi et al.	
5,577,037	A	11/1996	Takatori et al.	
5,579,311	A	11/1996	Chopping et al.	
5,586,177	A	12/1996	Farris et al.	
5,590,133	A *	12/1996	Billstrom et al.	370/349
5,592,477	A	1/1997	Farris et al.	
5,600,643	A	2/1997	Robrock, II	
5,619,561	A	4/1997	Reese	
5,623,491	A	4/1997	Skoog	
5,635,980	A	6/1997	Lin et al.	
5,636,261	A	6/1997	Fils	
5,640,446	A	6/1997	Everett et al.	
5,666,399	A	9/1997	Bales et al.	
5,673,262	A	9/1997	Shimizu	
5,689,550	A	11/1997	Garson et al.	
5,701,301	A	12/1997	Weisser, Jr.	
5,703,880	A	12/1997	Miura	
5,706,286	A	1/1998	Reiman et al.	
5,715,239	A *	2/1998	Hyodo et al.	370/248
5,765,108	A	6/1998	Martin et al.	
5,774,675	A *	6/1998	Uchida	709/246
5,784,371	A	7/1998	Iwai	
5,793,765	A	8/1998	Boer et al.	
5,825,780	A	10/1998	Christie	
5,828,666	A	10/1998	Focsaneanu et al.	
5,862,334	A	1/1999	Schwartz et al.	
5,872,779	A	2/1999	Vaudreuil	
5,872,785	A	2/1999	Kienberger	
5,920,562	A *	7/1999	Christie et al.	370/395.5
RE36,416	E	11/1999	Szlam et al.	
5,991,301	A	11/1999	Christie	
5,999,594	A	12/1999	Mizoguchi et al.	
6,031,840	A	2/2000	Christie, deceased et al.	
6,038,218	A	3/2000	Otsuka et al.	
6,175,574	B1	1/2001	Lewis	
6,181,703	B1	1/2001	Christie et al.	
6,324,179	B1	11/2001	Doshi et al.	
6,327,270	B1	12/2001	Christie et al.	
6,546,442	B1	4/2003	Davis et al.	
6,847,611	B1	1/2005	Chase et al.	
2004/0193329	A1	9/2004	Ransom et al.	
2006/0023676	A1	2/2006	Whitmore et al.	

FOREIGN PATENT DOCUMENTS

EP	0 488 399	6/1992
EP	0935856	8/1999
HU	71152	11/1995
JP	1013534	1/1989
JP	1300738	12/1989
JP	2215247	8/1990
JP	4180324	6/1992
JP	4196635	7/1992
JP	5327751	12/1993
JP	6006320	1/1994
JP	6209365	7/1994
JP	7177061	7/1995
JP	7250099	9/1995
JP	8149137	6/1996
WO	WO9214321	8/1992

OTHER PUBLICATIONS

Kuribayashi, Shin-ichi; Advanced Signaling Protocol for Broadband ISDN Services; Electronics and Communications In Japan; Part 1, vol. 78, No. 1, pp. 1-12.

Hungarian office action dated Jun. 23, 1999 citing Hungarian patent No. HU170127 for Hungarian Application No. P9900232; 2 pages.
Russian office action dated Apr. 22, 2002 citing Russian patent Nos. RU2013011 and RU2007880 for Russian Application No. 99112956; 6 pages.
Hiroshi Ishii and Masatoshi Kawarasaki; B-ISDN Signalling Protocol Capabilities; NTT Telecommunication Networks Laboratories; 1989; pp. 41.2.1-41.2.5.
Manu Bahl, et al.; "The Evolving Intelligent Interexchange Network—An SS7 Perspective;" Proceedings of the IEEE; Apr. 1992; pp. 637-643; vol. 80, No. 4.
IBM International Technical Support Organization; "Networking BroadBand Services (NBBS) Architecture Tutorial;" Jun. 1995; 248 pages; First Edition; Research Triangle Park, North Carolina, USA.

* cited by examiner

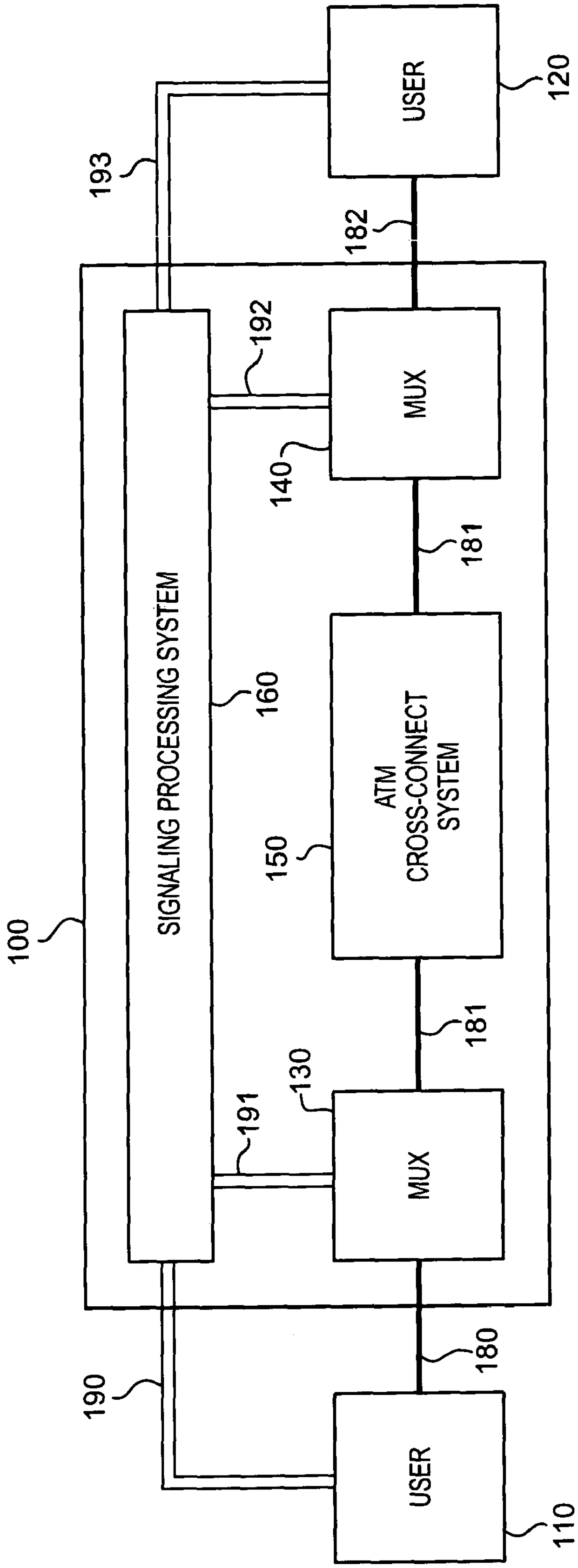
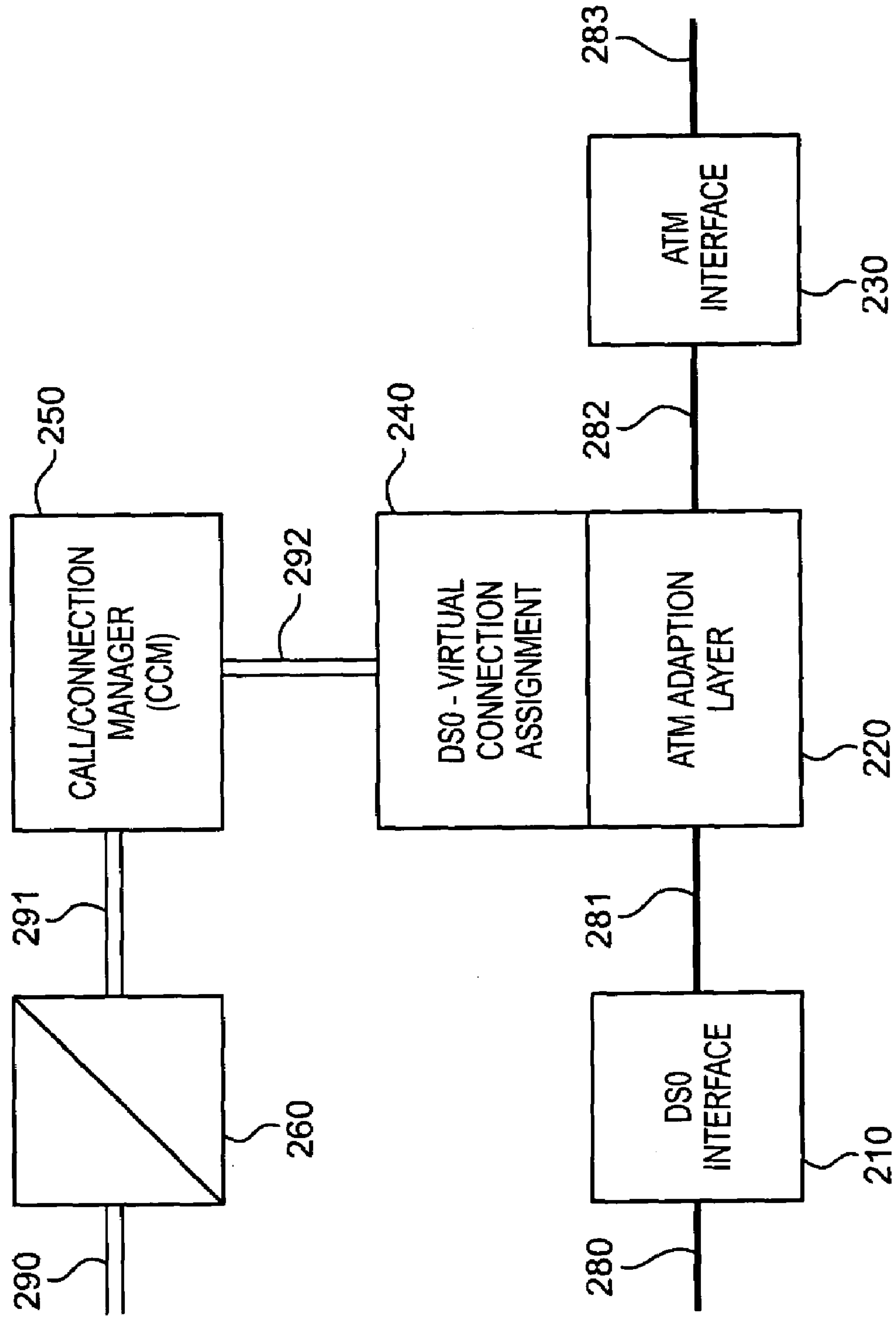
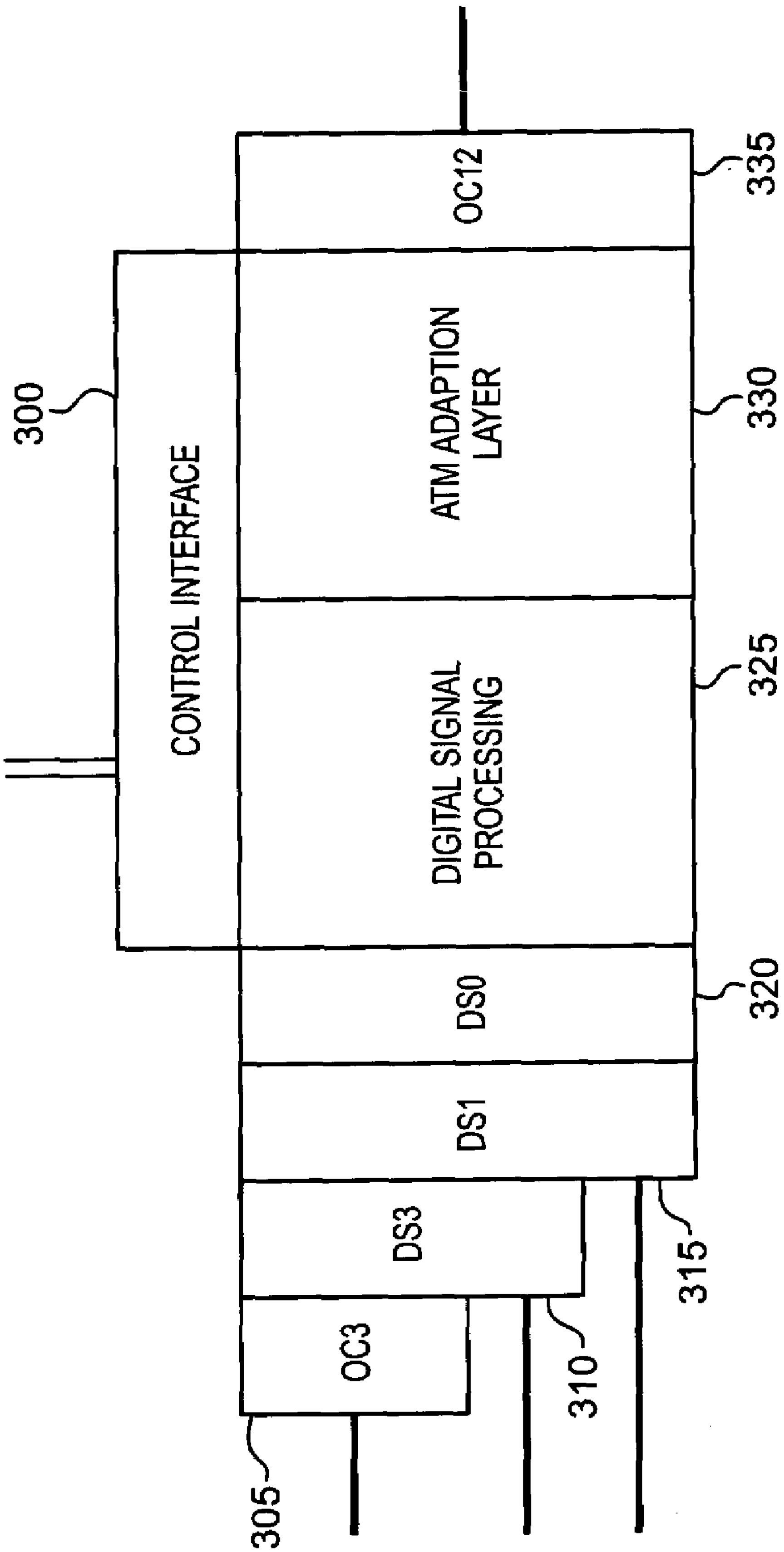

USER
120
193
182
192
MUX
140
181
SIGNALING PROCESSING SYSTEM
160
ATM
CROSS-CONNECT
SYSTEM
150
100
181
130
191
MUX
180
190
USER
110

FIG. 1



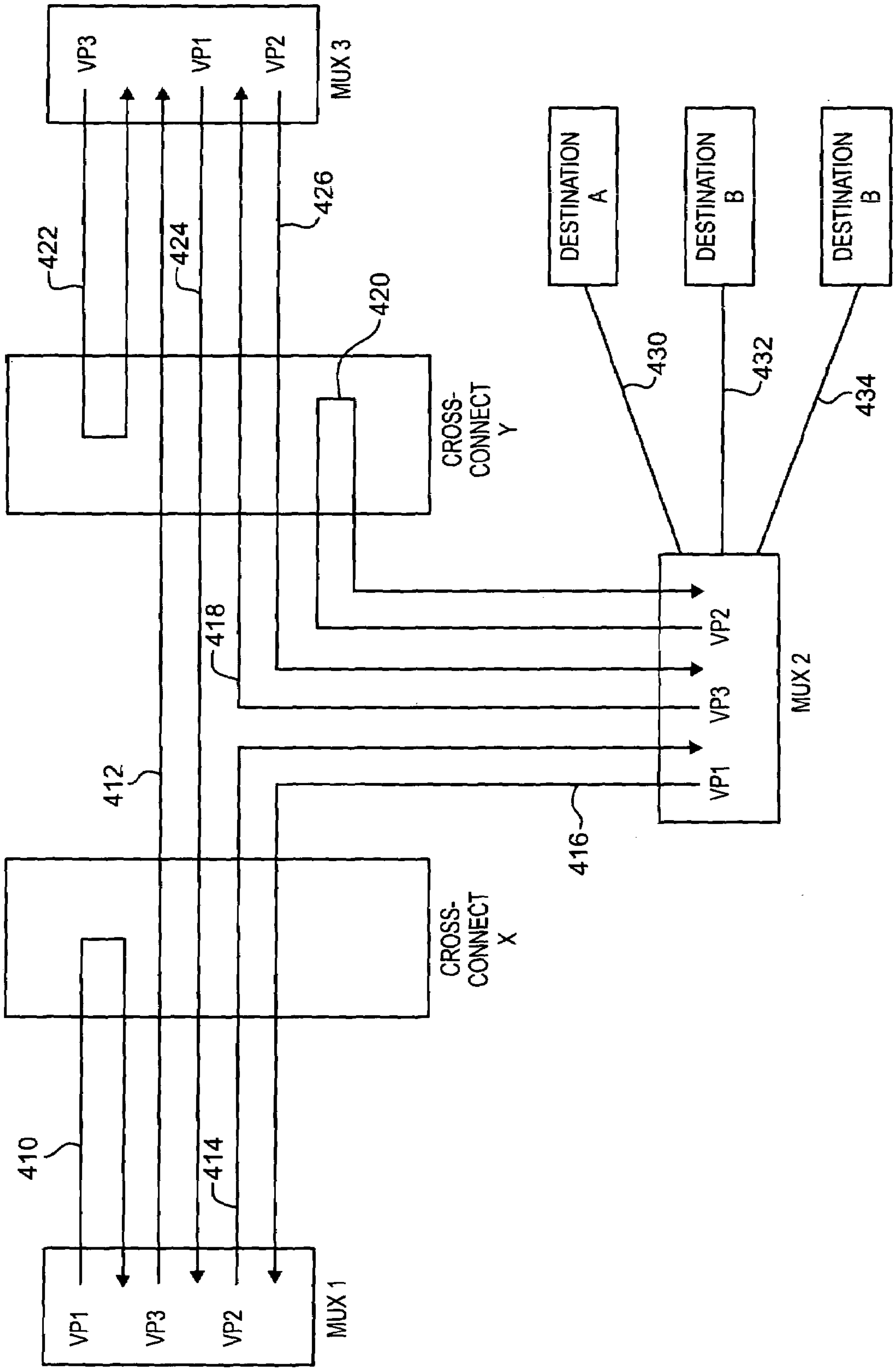
CALL/CONNECTION MANAGER (CCM)
250
DS0 - VIRTUAL CONNECTION ASSIGNMENT
240
ATM ADAPTION LAYER
220
ATM INTERFACE
230
DS0 INTERFACE
210
260
290
291
292
280
281
282
283

FIG. 2



OC12
335
ATM ADAPTION LAYER
330
300
CONTROL INTERFACE
DIGITAL SIGNAL PROCESSING
325
DS0
320
DS1
DS3
315
OC3
310
305

FIG. 3



MUX 3
VP3
VP1
VP2
422
424
426
420
CROSS-CONNECT Y
DESTINATION A
DESTINATION B
DESTINATION B
430
432
434
418
412
416
MUX 2
VP2
VP3
VP1
CROSS-CONNECT X
410
414
MUX 1
VP1
VP3
VP2

FIG. 4

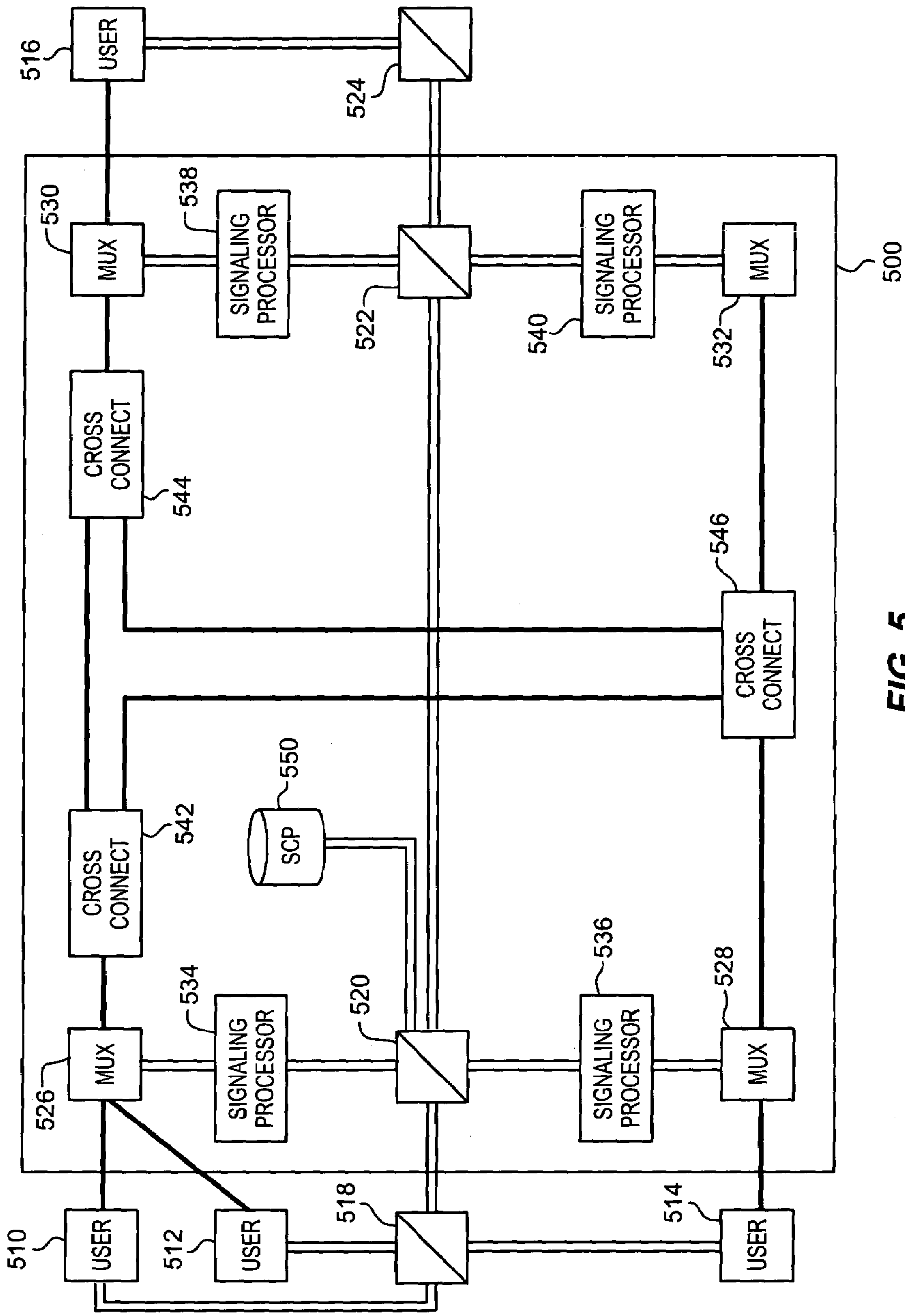
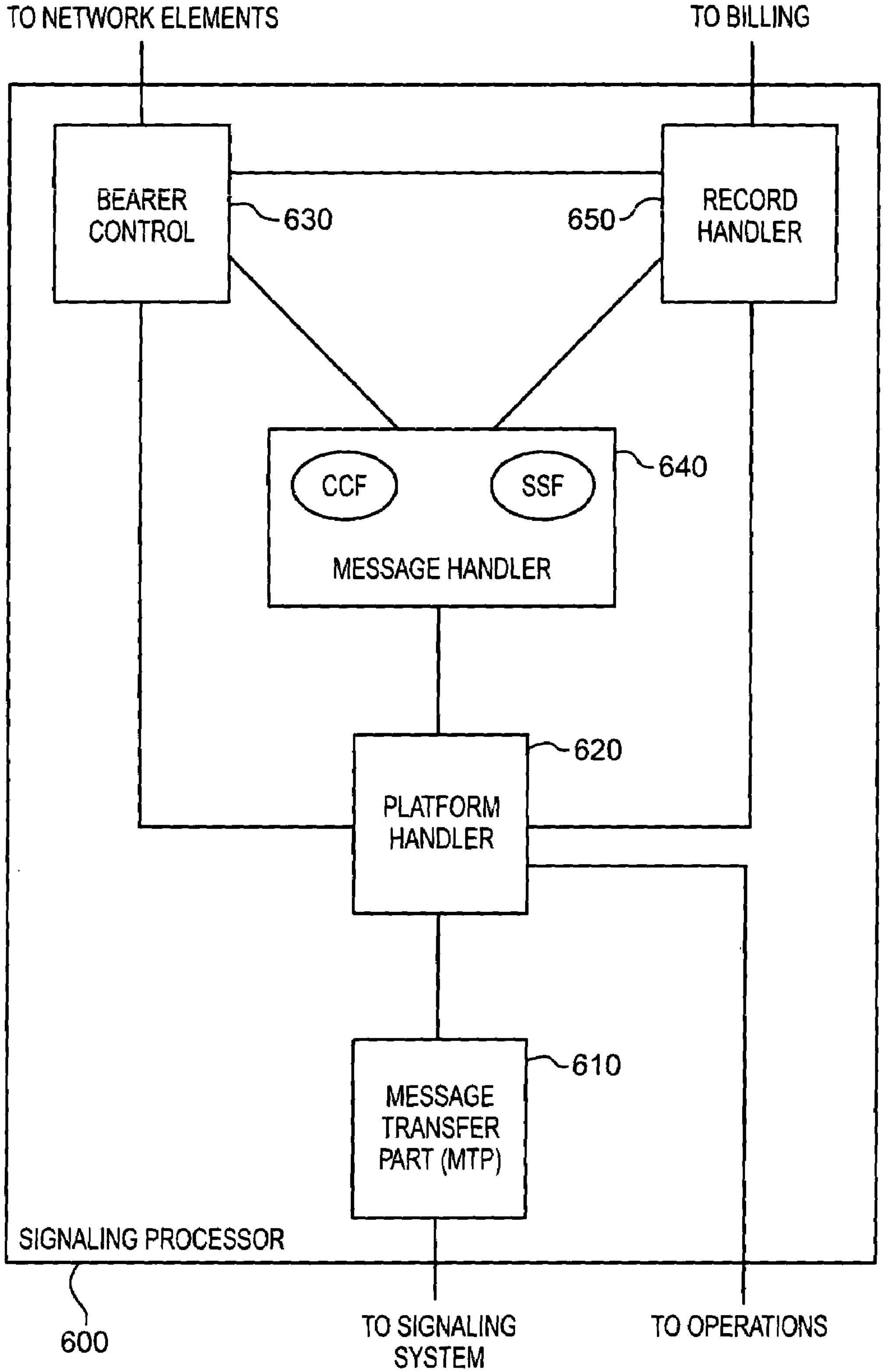
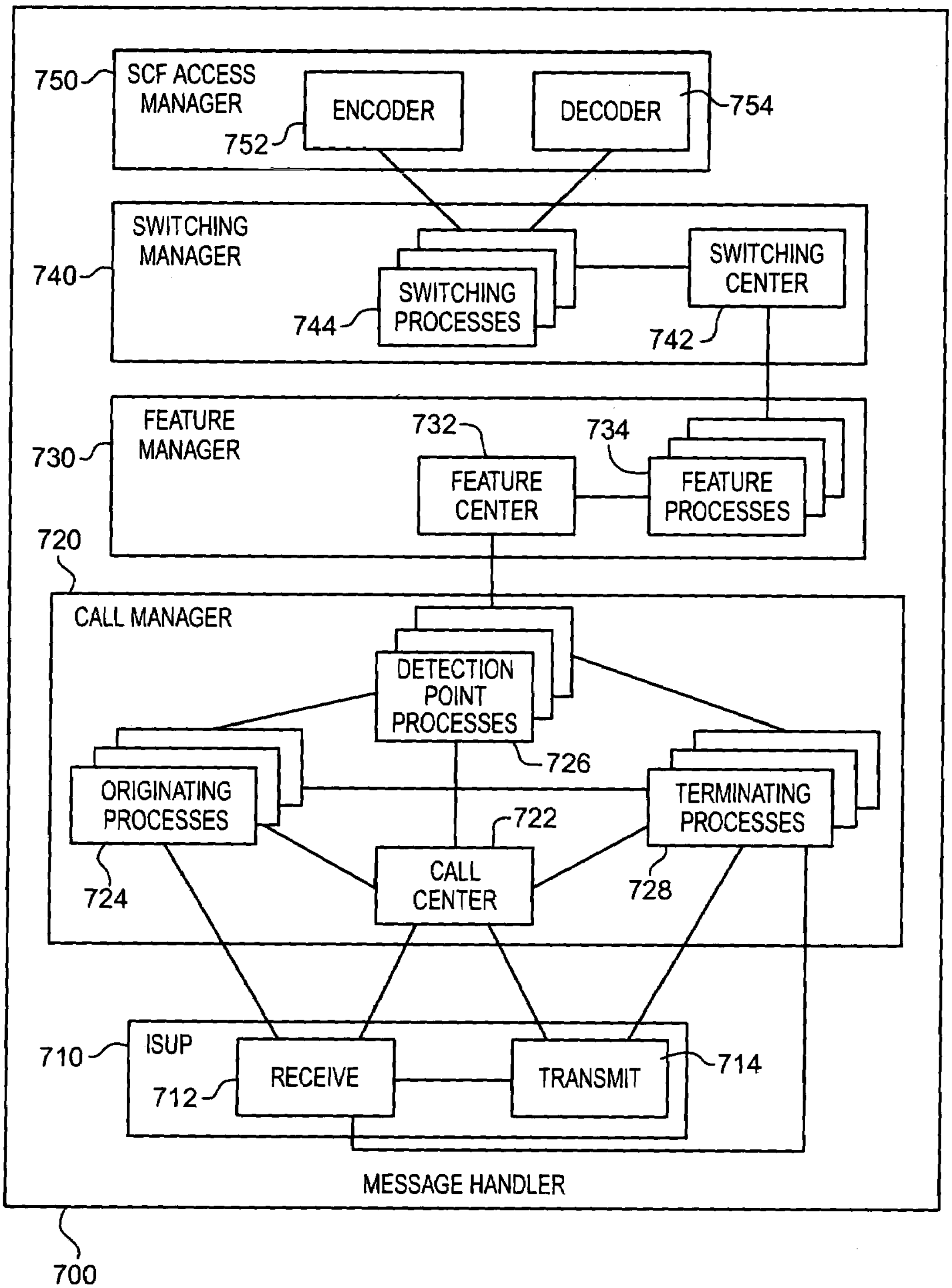

USER
516
524
530
MUX
538
SIGNALING PROCESSOR
522
540
SIGNALING PROCESSOR
MUX
532
500
CROSS CONNECT
544
546
CROSS CONNECT
550
SCP
CROSS CONNECT
542
534
SIGNALING PROCESSOR
520
536
SIGNALING PROCESSOR
528
MUX
526
MUX
510
USER
512
USER
518
514
USER

FIG. 5



TO NETWORK ELEMENTS
TO BILLING
BEARER CONTROL
630
650
RECORD HANDLER
CCF
SSF
MESSAGE HANDLER
640
620
PLATFORM HANDLER
610
MESSAGE TRANSFER PART (MTP)
SIGNALING PROCESSOR
600
TO SIGNALING SYSTEM
TO OPERATIONS

FIG. 6



750
SCF ACCESS MANAGER
ENCODER
752
DECODER
754
SWITCHING MANAGER
740
SWITCHING PROCESSES
744
SWITCHING CENTER
742
FEATURE MANAGER
730
732
734
FEATURE CENTER
FEATURE PROCESSES
720
CALL MANAGER
DETECTION POINT PROCESSES
726
ORIGINATING PROCESSES
TERMINATING PROCESSES
722
CALL CENTER
724
728
ISUP
710
RECEIVE
712
TRANSMIT
714
MESSAGE HANDLER
700

FIG. 7

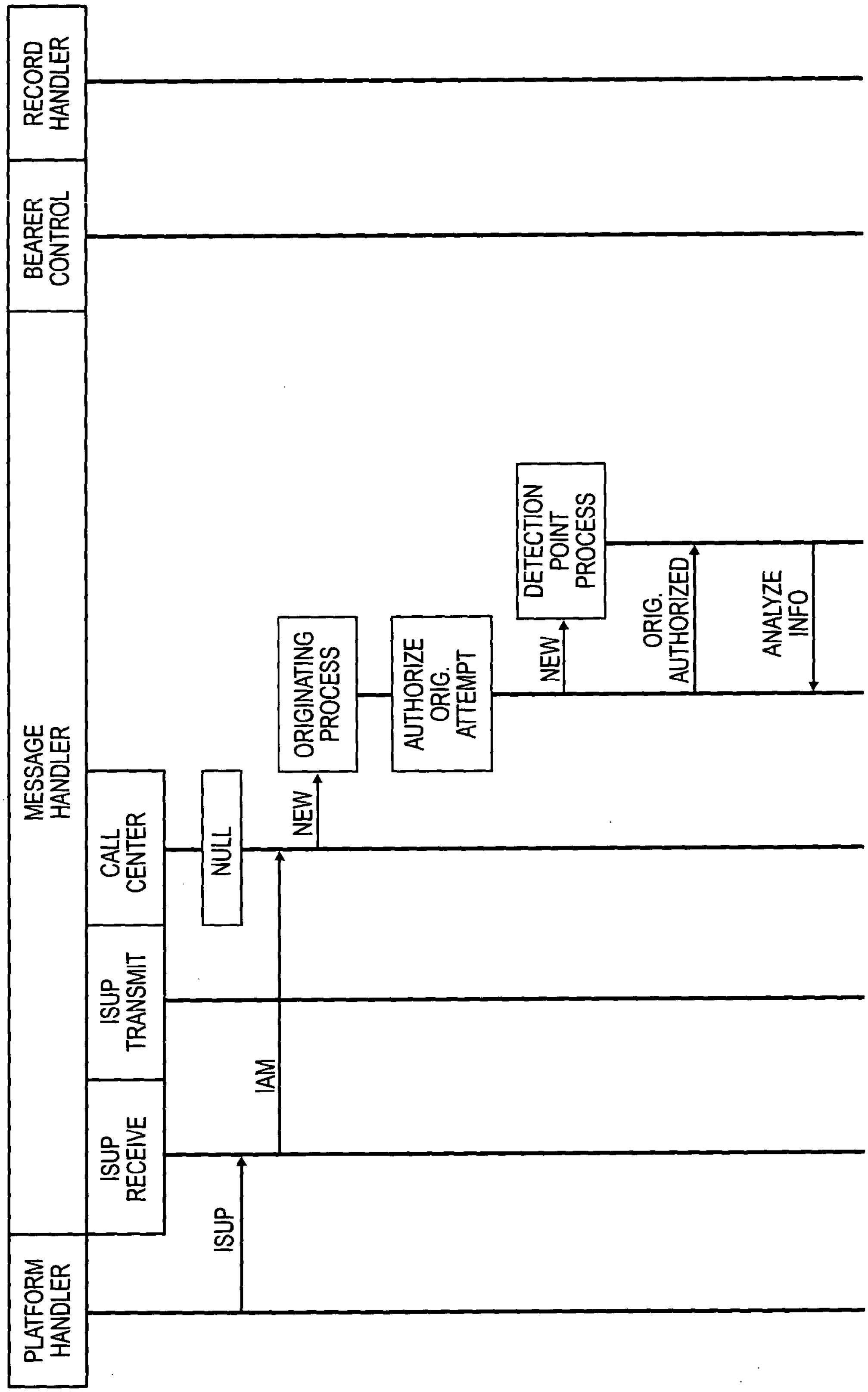

RECORD HANDLER
BEARER CONTROL
MESSAGE HANDLER
CALL CENTER
ISUP TRANSMIT
ISUP RECEIVE
PLATFORM HANDLER
NULL
ORIGINATING PROCESS
AUTHORIZE ORIG. ATTEMPT
DETECTION POINT PROCESS
NEW
ORIG. AUTHORIZED
ANALYZE INFO
NEW
IAM
ISUP

FIG. 8

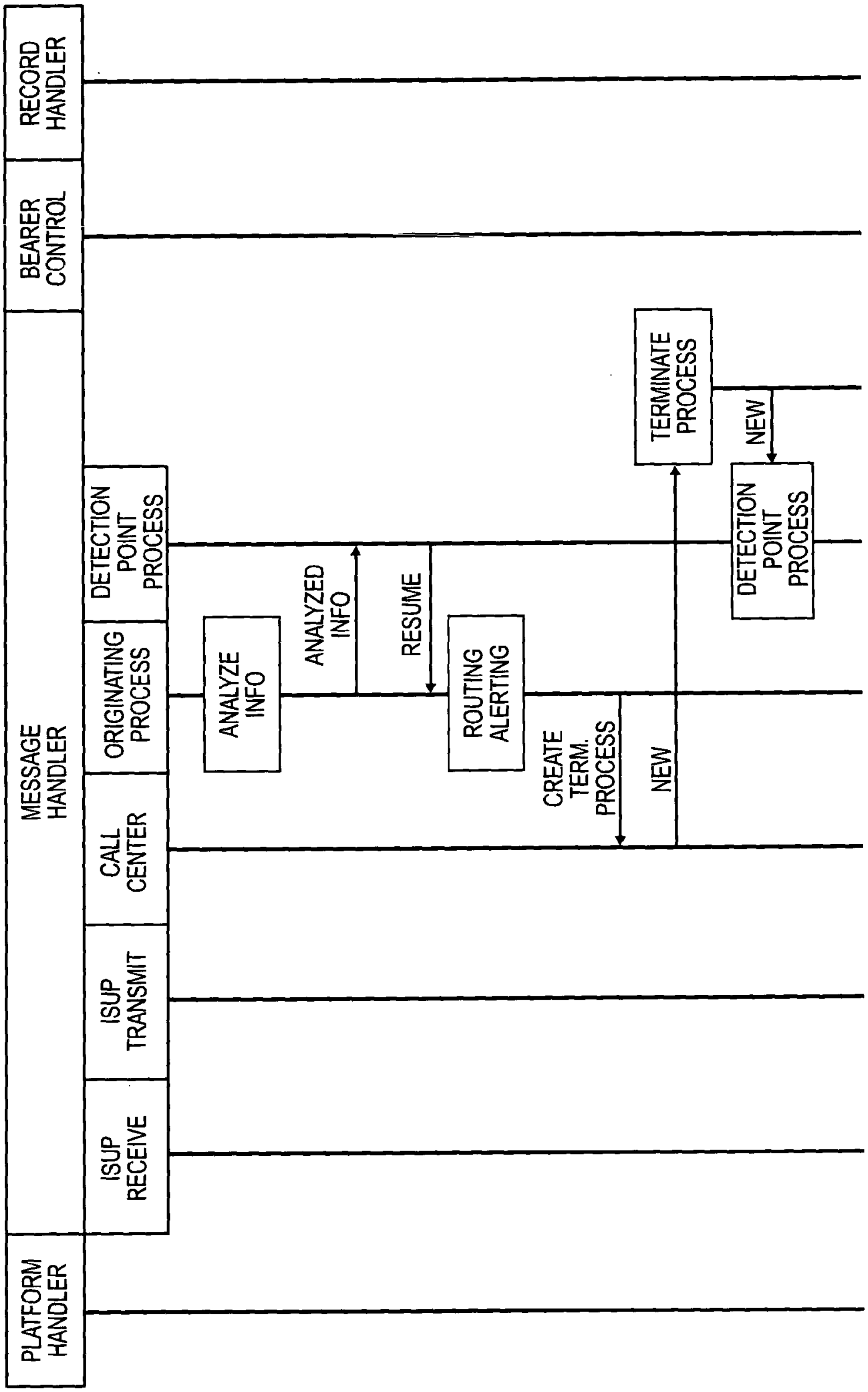

RECORD HANDLER
BEARER CONTROL
MESSAGE HANDLER
DETECTION POINT PROCESS
ORIGINATING PROCESS
CALL CENTER
ISUP TRANSMIT
ISUP RECEIVE
PLATFORM HANDLER
ANALYZE INFO
ANALYZED INFO
RESUME
ROUTING ALERTING
CREATE TERM. PROCESS
NEW
TERMINATE PROCESS
NEW
DETECTION POINT PROCESS

FIG. 9

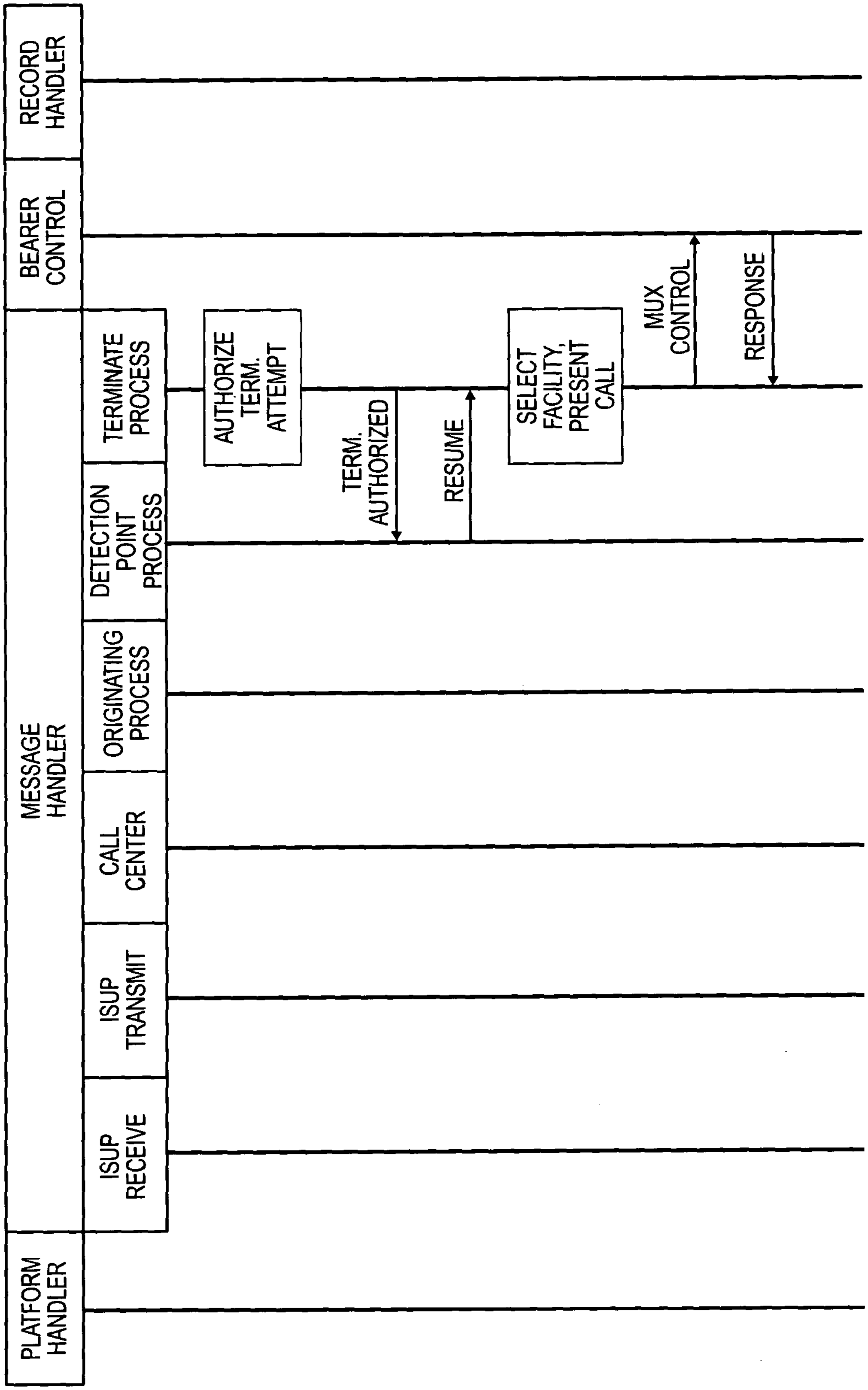

RECORD HANDLER
BEARER CONTROL
MESSAGE HANDLER
TERMINATE PROCESS
DETECTION POINT PROCESS
ORIGINATING PROCESS
CALL CENTER
ISUP TRANSMIT
ISUP RECEIVE
PLATFORM HANDLER
AUTHORIZE TERM. ATTEMPT
TERM. AUTHORIZED
RESUME
SELECT FACILITY, PRESENT CALL
MUX CONTROL
RESPONSE

FIG. 10

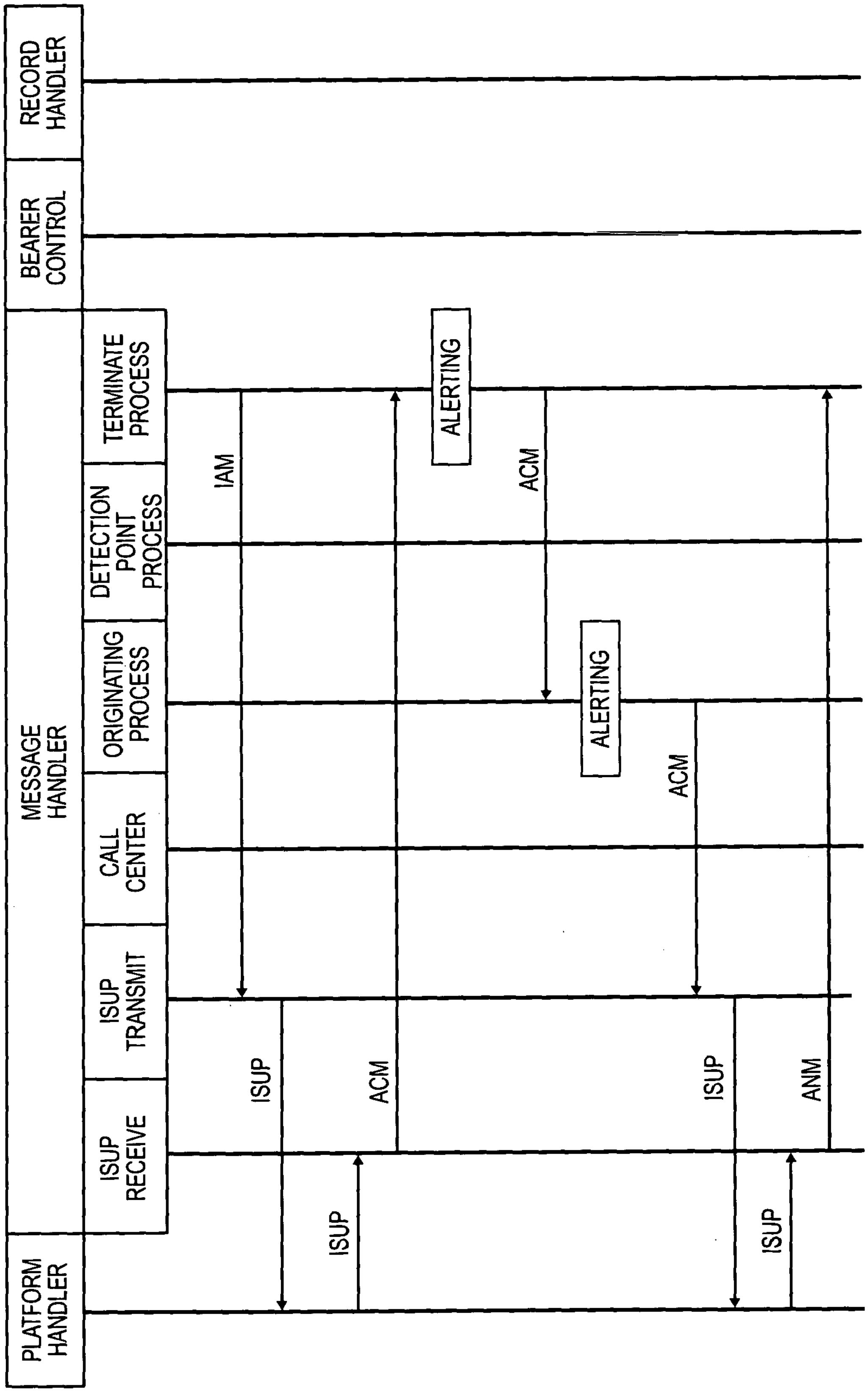

RECORD HANDLER
BEARER CONTROL
MESSAGE HANDLER
TERMINATE PROCESS
DETECTION POINT PROCESS
ORIGINATING PROCESS
CALL CENTER
ISUP TRANSMIT
ISUP RECEIVE
PLATFORM HANDLER
IAM
ALERTING
ACM
ALERTING
ACM
ISUP
ACM
ISUP
ANM
ISUP
ISUP

FIG. 11

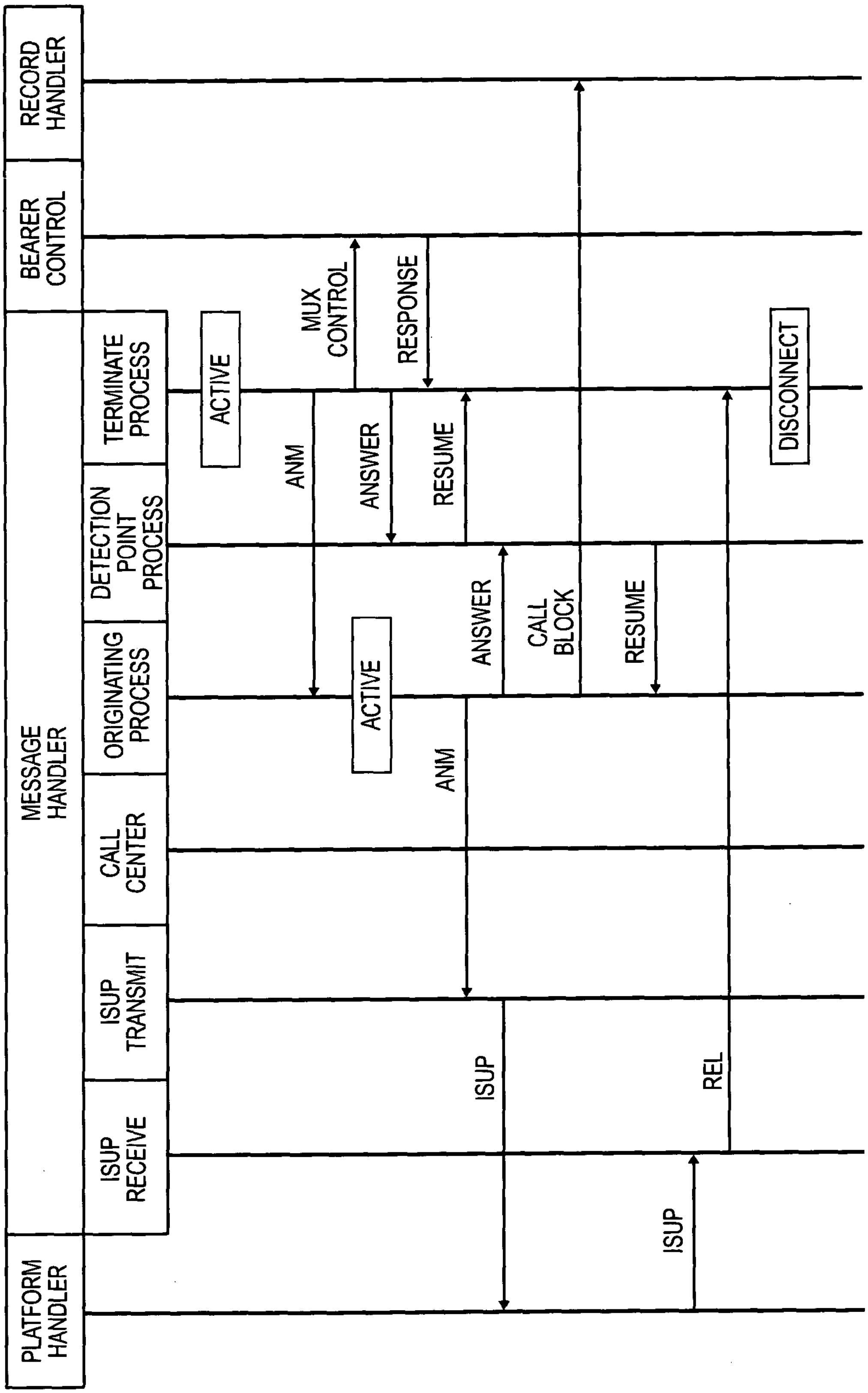

RECORD HANDLER
BEARER CONTROL
MESSAGE HANDLER
TERMINATE PROCESS
DETECTION POINT PROCESS
ORIGINATING PROCESS
CALL CENTER
ISUP TRANSMIT
ISUP RECEIVE
PLATFORM HANDLER
ACTIVE
MUX CONTROL
RESPONSE
ANM
ANSWER
RESUME
DISCONNECT
ACTIVE
ANSWER
CALL BLOCK
RESUME
ANM
ISUP
REL
ISUP

FIG. 12

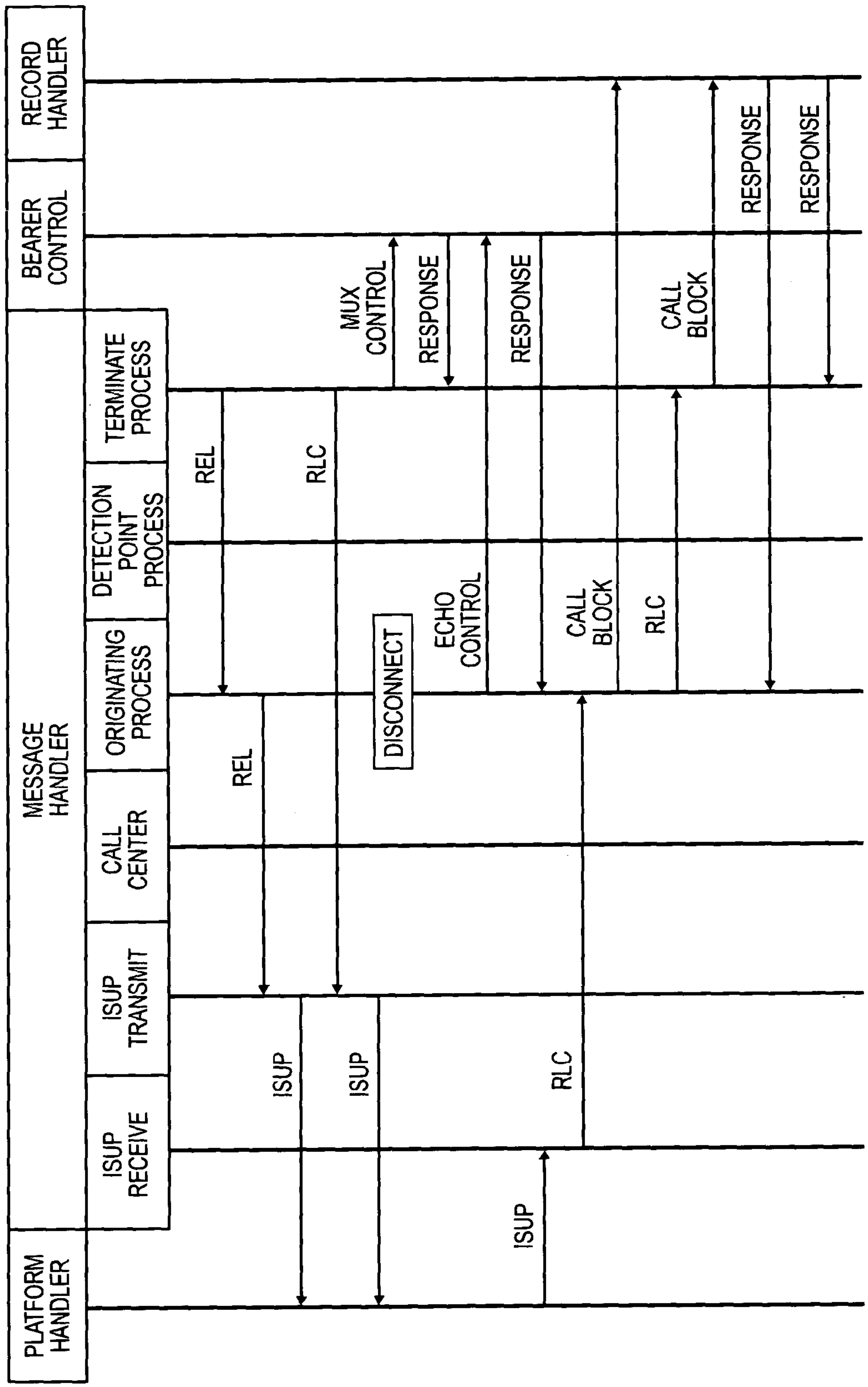

RECORD HANDLER
BEARER CONTROL
MESSAGE HANDLER
TERMINATE PROCESS
DETECTION POINT PROCESS
ORIGINATING PROCESS
CALL CENTER
ISUP TRANSMIT
ISUP RECEIVE
PLATFORM HANDLER
REL
RLC
REL
DISCONNECT
MUX CONTROL
RESPONSE
ECHO CONTROL
RESPONSE
CALL BLOCK
RLC
CALL BLOCK
RESPONSE
RESPONSE
ISUP
ISUP
RLC
ISUP

FIG. 13

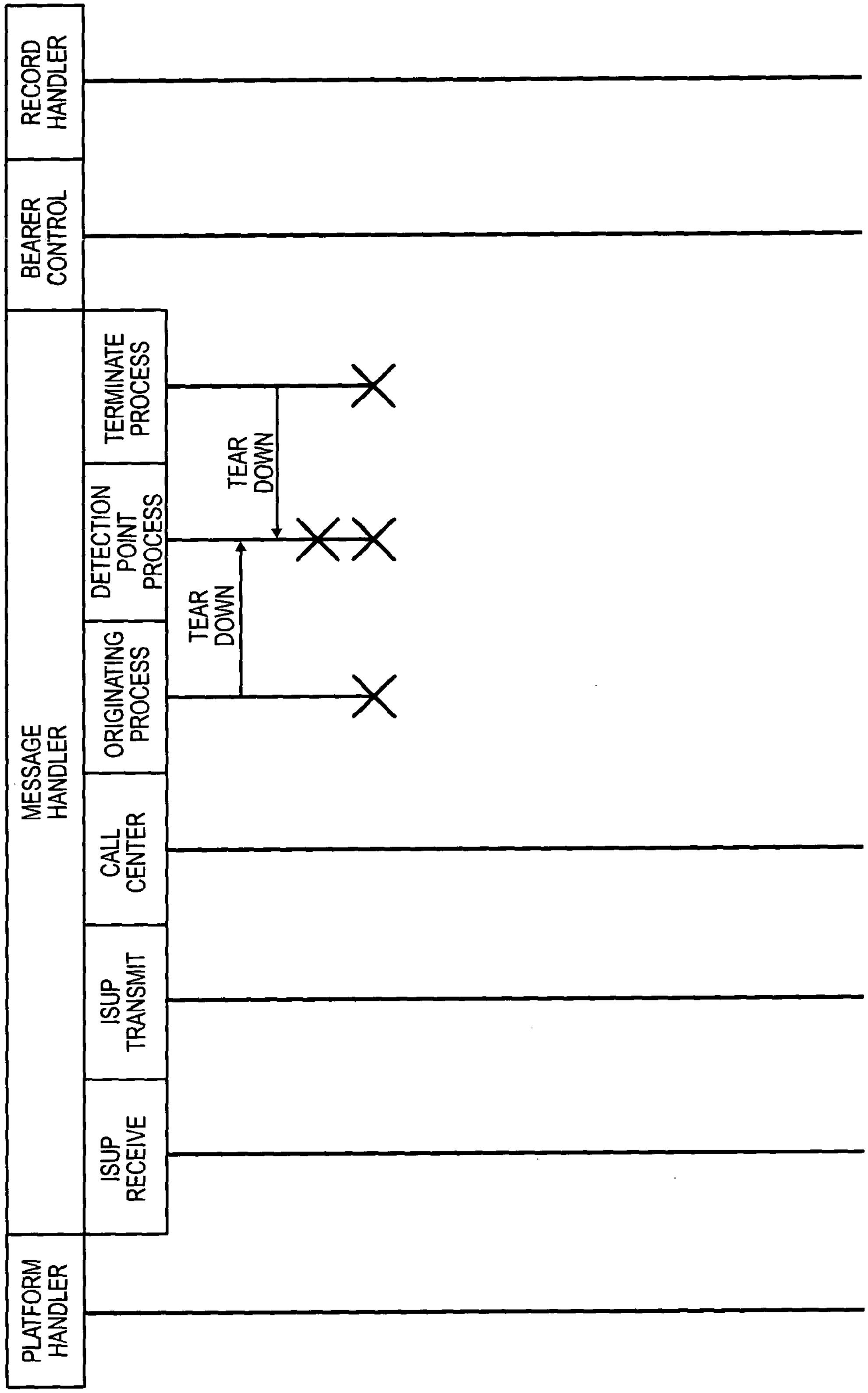

RECORD HANDLER
BEARER CONTROL
MESSAGE HANDLER
TERMINATE PROCESS
DETECTION POINT PROCESS
ORIGINATING PROCESS
CALL CENTER
ISUP TRANSMIT
ISUP RECEIVE
PLATFORM HANDLER
TEAR DOWN
TEAR DOWN

FIG. 14

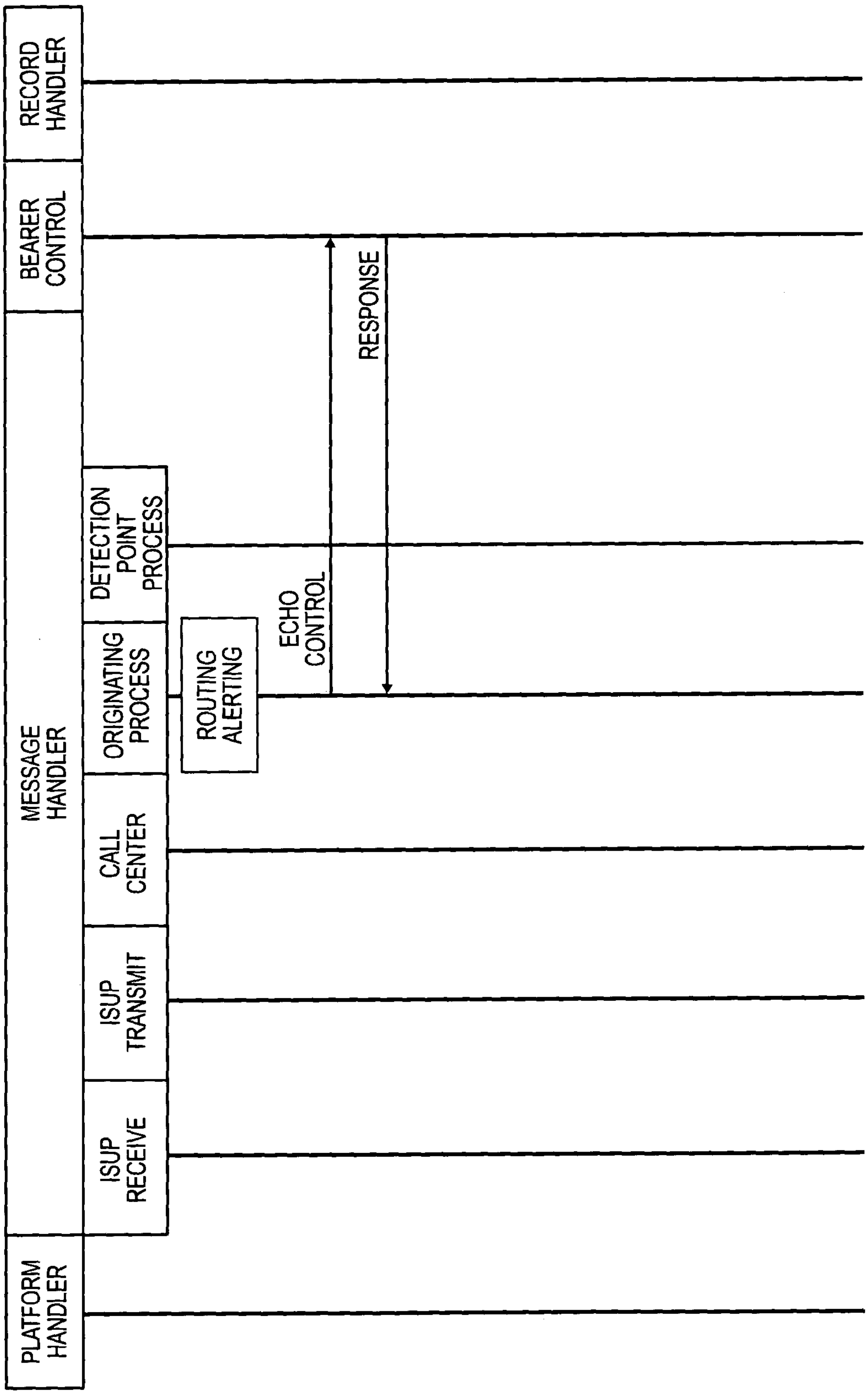

RECORD HANDLER
BEARER CONTROL
MESSAGE HANDLER
DETECTION POINT PROCESS
ORIGINATING PROCESS
CALL CENTER
ISUP TRANSMIT
ISUP RECEIVE
PLATFORM HANDLER
ROUTING ALERTING
ECHO CONTROL
RESPONSE

FIG. 15

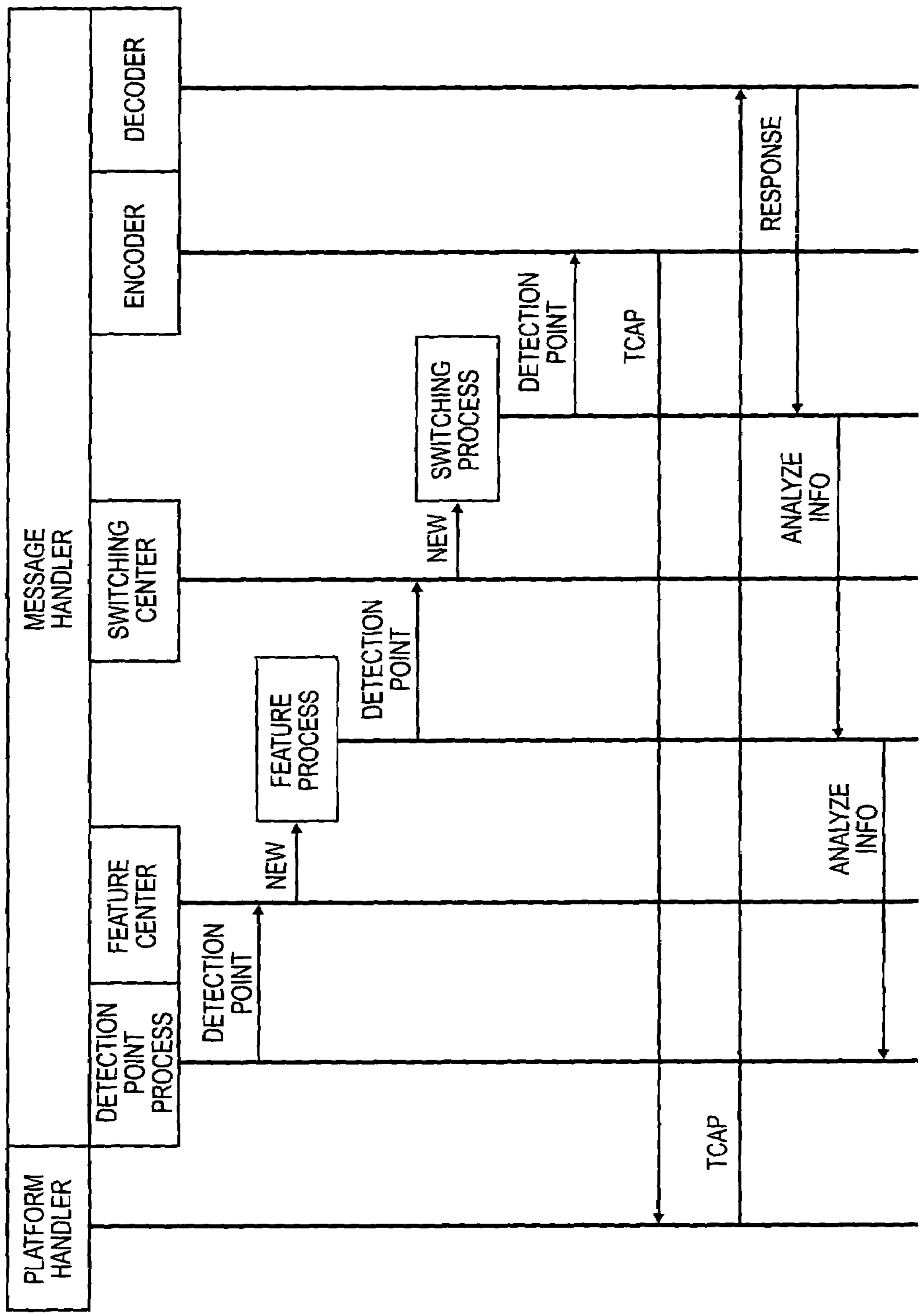

MESSAGE HANDLER
PLATFORM HANDLER
DETECTION POINT PROCESS
FEATURE CENTER
SWITCHING CENTER
ENCODER
DECODER
DETECTION POINT
NEW
FEATURE PROCESS
DETECTION POINT
NEW
SWITCHING PROCESS
DETECTION POINT
TCAP
RESPONSE
ANALYZE INFO
ANALYZE INFO
TCAP

FIG. 16

BROADBAND TELECOMMUNICATIONS SYSTEM

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation of prior application Ser. No. 09/497,719, entitled "BROADBAND TELECOMMUNICATIONS SYSTEM," filed Feb. 4, 2000, now U.S. Pat. No. 6,631,133, which is a continuation of patent application Ser. No. 08/594,660 filed Feb. 2, 1996, now U.S. Pat. No. 6,081,526; which is a continuation-in-part of patent application Ser. No. 08/525,897 filed Sep. 8, 1995, now U.S. Pat. No. 5,991,301 application Ser. No. 8/238,605 filed May 5, 1994. All of the above-related applications are hereby incorporated by reference into this application.

BACKGROUND

At present, Asynchronous Transfer Mode (ATM) technology is being developed to provide broadband switching capability for telecommunications calls. A call is a request for telecommunications services. Some ATM systems have used ATM cross-connects to provide virtual connections. Cross-connect devices do not have the capacity to process signaling. Signaling refers to messages that are used by telecommunications networks to set-up and tear down calls. Thus, ATM cross-connects cannot make connections on a call by call basis. As a result, connections through cross-connect systems must be pre-provisioned. They provide a relatively rigid switching fabric. Due to this limitation, ATM cross-connect systems have been primarily used to provide dedicated connections, such as permanent virtual circuits (PVCs) and permanent virtual paths (PVPs). But, they do not provide ATM switching on a call by call basis as required to provide switched virtural circuits (SVCs) or switched virtual paths (SVPs). Those skilled in the art are well aware of the efficiencies created by using SVPs and SVCs as opposed to PVCs and PVPs. SVCs and SVPs utilize bandwidth more efficiently.

ATM switches have also been used to provide PVCs and PVPs. Since PVCs and PVPs are not established on a call-by-call basis, the ATM switch does need to use its call processing or signaling capacity. ATM switches require both signaling capability and call processing capability to provide SVCs and SVPs. In order to achieve virtual connection switching on a call by call basis, ATM switches are being developed that can process calls in response to signaling to provide virtual connections for each call. These systems cause problems because they must be very sophisticated to support current networks. These ATM switches must process high volumes of calls and transition legacy services from existing networks. An example would be an ATM switch that can handle large numbers of POTS, 800, and VPN calls.

Currently, ATM multiplexers are capable of interworking traffic of other formats into the ATM format. These are known as ATM interworking multiplexers. ATM multiplexers are being developed that can interwork traffic into ATM cells and multiplex the cells for transport over an ATM network. One example of an application of these muxes is provided by T1 transport over an ATM connection. Traffic that leaves the switch in T1 format is muxed into ATM cells for transport over a high speed connection. Before the cells reach another switch, they are converted back into the T1 format. Thus, the ATM mux is used for high speed transport. The ATM mux is not used to select virtual connections on a call-by-call basis. Unfortunately, there is not a telecommunications system that can provide ATM switching on a call by call basis without relying on the call processing and signaling capability of an ATM switch.

One solution to the above-described problems is disclosed in the parent applications cross-referenced above. This application disclosed the call by call control of the interworking point. The present invention provides enhancements and improvements to those systems.

SUMMARY

The invention includes a method of operating a telecommunications system to provide a call with a virtual connection. The invention is applicable where a user places the call by sending signaling for the call to the telecommunications system and by transmitting user information to the telecommunications system over a particular connection for the call. The telecommunications system comprises an ATM interworking multiplexer and a signaling processor coupled to the ATM interworking multiplexer. The method comprises receiving the signaling for the call into the signaling processor and processing the signaling to select the virtual connection. The method further includes generating a control message in the signaling processor to identify the particular connection and the selected virtual connection, and transmitting the control message to the ATM interworking multiplexer. The method further includes receiving the user information for the call from the particular connection into the ATM interworking multiplexer and converting the user information into ATM cells that identify the selected virtual connection in response to the control message. The method further includes transmitting the ATM cells from the ATM interworking multiplexer over the selected virtual connection.

The invention also includes a telecommunications system to provide a call received over a particular connection with a virtual connection in response to signaling for the call. The telecommunications system comprises a signaling processor operable to receive and process the signaling to select the virtual connection for the call, and to generate and transmit a control messages that identifies the particular connection and the selected virtual connection. The system further includes an ATM interworking multiplexer operable to receive user information from the particular connection, convert the user information into ATM cells that identify the selected virtual connection in response to the new signaling, and to transmit the ATM cells from the ATM interworking multiplexer over the selected virtual connection. The invention further includes a means for coupling the signaling processor and the ATM interworking multiplexer that is operable to transfer the control message from the signaling processor to the ATM interworking multiplexer. In some embodiments the system also includes an ATM cross-connect system connected to the ATM interworking multiplexer and configured to provide a plurality of virtual connections to the ATM interworking multiplexer.

In various embodiments, the invention accepts calls placed over DS0 voice connections and provides virtual connections for the calls. In this way, broadband virtual connections can be provided to narrowband traffic on a call-by-call basis without requiring the call processing and signaling capability of an ATM switch.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of a version of the present invention.

FIG. **2** is a block diagram of a version of the present invention.

FIG. **3** is a block diagram of a version of the present invention.

FIG. **4** is a logic diagram of a version of the present invention.

FIG. **5** is a block diagram of a version of the present invention.

FIG. **6** is a logic diagram of a version of the invention.

FIG. **7** is a logic diagram of a version of the invention.

FIG. **8** is a message sequence chart for a version of the invention.

FIG. **9** is a message sequence chart for a version of the invention.

FIG. **10** is a message sequence chart for a version of the invention.

FIG. **11** is a message sequence chart for a version of the invention.

FIG. **12** is a message sequence chart for a version of the invention.

FIG. **13** is a message sequence chart for a version of the invention.

FIG. **14** is a message sequence chart for a version of the invention.

FIG. **15** is a message sequence chart for a version of the invention.

FIG. **16** is a message sequence chart for a version of the invention.

DETAILED DESCRIPTION

For purposes of clarity, the term "connection" will be used to refer to the transmission media used to carry user traffic. The term "link" will be used to refer to the transmission media used to carry signaling or control messages. On the Figures, connections are shown by a single line and signaling links and data links are shown by double lines.

FIG. **1** depicts a version of the present invention. Shown is telecommunications system **100**, user **110**, and user **120**. Telecommunications system **100** includes ATM interworking multiplexer (mux) **130**, mux **140**, ATM cross-connect system **150**, and signaling processing system **160**. User **110** is connected to mux **130** by connection **180**. Mux **130** and mux **140** are connected through cross-connect system **150** by connection **181**. Mux **140** is connected to user **120** by connection **182**. Signaling processing system **160** is linked to user **110** by link **190**, to mux **130** by link **191**, to mux **140** by link **192**, and to user **120** by link **193**.

Those skilled in the art are aware that large networks have many more components than are shown. For example, there would typically be a multitude of virtual connections through ATM cross-connect system **150**. The number of these components has been restricted for clarity. The invention is fully applicable to a large network.

User **110** and user **120** could be any entity that supplies telecommunications traffic to network **100**. Some examples would be a local exchange carrier (LEC) switch or customer premises equipment (CPE). Connections **180** and **182** represent any connection that might be used by user **120** to access system **100**. Typically, the user traffic would be provided to system **100** in DS3, format with embedded DS0 circuits, but could also include formats such as DS1, a fractional DS1, 56 kbit data, DS2, clear DS3, E1, E3, or even an SDH or SONET signal with a DS3 or VT based structure. As such, these connections are periodically referred to as access connections. Links **190** and **193** are any links capable of transferring signaling messages with examples being Signaling System #7 (SS7) links or C7 links. ATM cross-connect system **150** is any system that provides a plurality of virtual connections. Such a system could be comprised of individual ATM cross-connect devices interconnected by ATM connections using DS3 or SONET for transport. An example of an ATM cross-connect is the NEC Model 10. Connection **181** could be any virtual connection. In ATM, virtual connections can be designated by a Virtual Path Identification and/or and Virtual Channel Identification in the cell header. Ranges of VPI/VCI may be used to designate the virtual connection. Typically, the virtual connection would use DS1, DS3, or SONET for transport. ATM cross-connect system **150** would be pre-provisioned to provide a plurality of virtual connections through the cross-connect system, and virtual connection **181** represents one of these connections. As virtual connections are logical paths, many physical paths can be used based on the pre-provisioning of ATM cross-connect system **150**. Links **191** and **192** could be any links capable of transporting control messages. Examples of such links could be SS7 links, UDP/IP over an ethernet connection, or a bus arrangement using a conventional bus protocol. The components described in this paragraph are known in the art.

Signaling processing system **160** is any processing platform that can receive and process signaling to select virtual connections, and then generate and transmit messages to identify the selections. Various forms of signaling are contemplated by the invention, including SS7, C7, and user to network interface (UNI) signaling. A preferred embodiment of the signaling processor is discussed in detail toward the end of the disclosure.

Mux **130** could be any muxing system operable to place user information arriving over connection **180** on the virtual connection selected by signaling processing system **160**. Typically, this involves receiving control messages from signaling processing system **160** that identify assignments of virtual connections to access connections on a call by call basis. The mux would convert user traffic from access connection **180** into ATM cells that identify the selected virtual connection. Mux **140** is similar to mux **130**. A preferred embodiment of these muxes are also discussed in detail below.

The system would operate as follows for a call from user **110** to user **120**. User **110** would seize a connection to system **100**. The connection is represented by connection **180** to mux **130**. Although, only one connection is shown for purposes of clarity, numerous connections would typically be available for seizure. User **110** would also send a signaling message over link **190** to system **100** initiating the call. This signaling would identify seized connection **180**. Signaling processing system **160** would process the message. Such processing could include validation, screening, translating, route selection, echo control, network management, signaling, and billing. In particular, a virtual connection through ATM cross-connect system **150** from mux **130** to mux **140** would be selected, and a connection from mux **140** to user **120** would also be selected. Although many possible connections would be available, only the selected connections are shown—connection **181** and connection **182**. Generally, the selection is based on the dialed number, but call processing can entail many other factors with a few examples being the caller's number, destination conditions, network loads and user routing instructions. Also, the dialed number may be translated to make the selection. Signaling processing system **160** would send a control message over link **191** to mux **130** that identifies seized connection **180** and selected connection **181**. Signaling processing system

160 would send a control message over link **192** to mux **140** that identifies selected connections **181** and **182**.

If required, user **120** would receive signaling to facilitate completion of the call. The signaling from signaling processing system **160** would indicate that system **100** was connecting to user **120** over connection **182**. Typically, user **120** would accept and acknowledge the connection in a signaling message back to system **100**.

In the above procedure, mux **130** would receive control messages from signaling processing system **160** identifying connection **180** as the access connection and connection **181** as the selected virtual connection through ATM cross-connect system **150**. Mux **130** would convert the user information from connection **180** into ATM cells. Mux **130** would designate connection **181** in the cell headers. Connection **181** would have been previously provisioned through ATM cross-connect system **150** from mux **130** to mux **140**.

Mux **140** would receive control messages from signaling processing system **160** identifying connection **181** as the selected virtual connection and connection **182** as the selected access connection to user **120**. Mux **140** would convert cells arriving on connection **181** to user information suitable for connection **182** to user **120**. Although the above example employs two muxes, a single mux could be employed for calls that enter and exit system **100** through the same mux. In this case, the ATM system would simply provide a virtual connection back to the same mux. In alternative embodiments, the mux could even cross-connect the two access connections in and out of the network. This cross-connection of two access connections in a single mux could use an internal cell bus or be accomplished by cross-connection without using ATM.

From the above discussion, it can be seen that multiple virtual connections can be pre-provisioned through an ATM cross-connect system to interconnect ATM interworking multiplexers. When a user places a call, one of the virtual connections is selected for the call by the signal processing system and identified to the appropriate muxes. The muxes convert the user information into cells that identify the selected connection. As such, user information can be switched through an ATM fabric on a call by call basis. The system does not require the call processing or signaling capabilities of an ATM switch (although an ATM switch could be used to provide the virtual connections without using its call processing and signaling functions). The system can also implement enhanced services such as N00 and virtual private network (VPN).

FIG. **2** depicts another embodiment of the invention. In this embodiment, the user information from the access connection is capable of being muxed to the DS0 level, but this is not required in other embodiments. Additionally, SS7 signaling is used in this embodiment, but other signaling protocols, such as C7 or UNI signaling, are also applicable to the invention. Shown are DS0 interface **210**, ATM adaption layer (AAL) **220**, ATM interface **230**, DS0—virtual connection assignment **240**, call/connection manager (CCM) **250** and signal transfer point (STP) **260**. Also shown are connections **280-283** and links **290-292**.

Connection **280** could by any connection or group of connections that contain information that can be converted to DS0 format. Examples of these connections are OC-3, VT1.5, DS3, and DS1. DS0 interface **210** is operable to convert user information in these formats into the DS0 format. AAL **220** comprises both a convergence sublayer and a segmentation and reassembly (SAR) layer. AAL **220** is operational to accept the user information in DS0 format from DS0 interface **210** and convert the information into ATM cells. AALs are known in the art and information about AALs is provided by International Telecommunications Union (ITU) document I.363.1. An AAL for voice is also described in patent application Ser. No. 08/395,745, filed on Feb. 28, 1995, entitled “Cell Processing for Voice Transmission”, and hereby incorporated by reference into this application. ATM interface **230** is operational to accept ATM cells and transmit them over connection **283**. Connection **283** is a standard DS1, DS3 or SONET connection transporting ATM cells. Connection **281** is operational for the DS0 format and connection **282** is operational to transfer ATM cells.

It can be seen that a communications path through connections **280-283** could be established to carry user information. Although the communications path has been described from connection **280** to connection **283**, the invention contemplates components that are also operational to perform reciprocal processing in the reverse direction. If the communications path is bi-directional, user information in ATM cells arriving on connection **283** would be processed for output on connection **280** in the appropriate format. Those skilled in the art will appreciate that separate connections could also be set-up in each direction, or that only a connection in one direction may be required. These components and their operation are known in the art.

Signaling links **290** and **291** are SS7 links. Link **292** is a data link with an example being an ethernet connection transporting UDP/IP, although a bus arrangement could be used if the CCM and the mux are physically integrated. STP **260** is device that routes signaling messages. STPs are well known in the art. CCM **250** would be identified by its own signaling point code. Point codes designate various points in the network and they are used to route signaling messages to these points. STP **260** would route signaling messages with the point code of CCM **250** to CCM **250**. The signaling protocol could be based on narrowband Integrated Services Digital Network ISDN) User Part (N-ISUP) employing Message Transfer Part (MTP) levels 1-3. In some embodiments, the signaling uses N-ISUP messages transported over broadband connections. This would entail a protocol stack of MTP3—Signaling ATM Adaption Layer (SAAL)—ATM. In other words, N-ISUP messages from MTP3 would be encapsulated into ATM cells for transport.

In some embodiments, STP **260** may also convert point codes between the point code for CCM **250** and other point codes. This is so messages sent to other network elements can be diverted to the CCM, and so that messages sent from the CCM can be masked with a point code that is recognized by other network elements. Although point code conversion is not essential, it facilitates the transition of a network to the system of the invention. The conversion could be implemented through a conversion table located between the discrimination function and the routing function of the MTP level 3 function of STP **260**. Mapping would be implemented on a linkset by linkset basis, so affected linksets would flag all incoming messages. Flagged messages would access the conversion table. The conversion table would typically convert the destination point code of the message to that of CCM **250**, so that the route function of MTP 3 would forward the message to CCM **250**. Point code conversion could be based on many factors with a few examples being the destination point code, the origination point code, the signaling link, the circuit identification code, the message type, and various combinations of these and other factors. For example, any SS7 ISUP messages with particular OPC/DPC combinations could have the DPC converted

to the point code of CCM **250**. These signaling messages would then be routed to CCM **250** by STP **260**. In some scenarios, the origination point code of a message leaving CCM **250** may need to be converted to mask CCM **250** as another point code (i.e. a retired switch). The point code mapping would also have to be implemented within the Signaling Network Management function. In some situations, transfer restricted or transfer prohibited messages will need point code conversion to mask the CCM as the sender. One version of a suitable STP is disclosed in U.S. patent application Ser. No. 08/525,868 entitled "Telecommunications Apparatus, System, and Method with Enhanced Signal Transfer Point", which is hereby incorporated by reference into this application.

CCM **250** is a signaling processor that operates as discussed above. A preferred embodiment of CCM **250** is provided later. In this embodiment CCM **250** would be operable to receive and process SS7 signaling to select connections, and to generate and transmit control messages identifying the selections. Preferably, a single CCM would be associated with a single mux or a group of muxes.

Assignment **240** is a control interface that accepts messages from CCM **250**. In particular, assignment **240** receives and identifies DS0/virtual connection assignments in the messages from link **292**. These assignments are provided to AAL **220** for implementation. As such, AAL **220** obtains the virtual path identifier (VPI) and virtual channel identifier (VCI) for each call from assignment **240**. AAL **220** also obtains the identity of the DS0 for each call (or the DS0s for an Nx64 call). AAL **220** then converts user information between the identified DS0 and the identified ATM virtual connection. Acknowledgments that the assignments have been implemented may be sent back to CCM **250** if desired. It should be noted that these assignments are dynamically received and implemented on a call-by-call basis. This is in contrast to conventional interworking muxes that operate using static assignments. The static assignments can be altered through a provisioning process, but provisioning is not dynamically done on a call-by-call basis.

In operation, calls are processed as follows. Signaling messages for calls arrive on link **290** and are routed by STP **260** to CCM **250**. Access connections are typically seized contemporaneously with the signaling. All of these connections are represented by connection **280**. DS0 interface **210** would convert the traffic on connection **280** into the DS0 format and provide the DS0s to AAL **220** over connection **281**.

The signaling received by CCM **250** would identify the access connections for the calls (i.e. the particular DS0s on connection **280**), and contain call information, such as dialed numbers. CCM **250** would process the signaling and select connections for the calls. Since multiple virtual connections are pre-provisioned from ATM interface **230** to the other destinations in the network, CCM **250** can select a virtual connection to the destination. The selection process can be accomplished through table look-ups. For example, a table could be used to translate a portion of the dialed number into a VPI. The VCI would be selected based on the available VCIs in the selected VPI. The VPI/VCI combination would correspond to a unique virtual connection pre-provisioned from ATM interface **230** to the appropriate network destination. The selections represent the DS0—virtual connection assignments that are provided to assignment **240** over link **292**.

Assignment **240** accepts the DS0—virtual connection assignments and provides them to AAL **220**. When AAL **220** receives a particular assignment, it places user information bytes from the designated DS0 into cells and appends a header to the cells that identifies the designated VPI/VCI. The cells are provided to ATM interface **230** over connection **282**. ATM interface **230** accepts the cells and places them within the transport format for connection **283**. The cells are then transported over the selected virtual connection to the appropriate destination.

Calls also exit the network through connection **280**. In this case, other CCMs at the origination points select the virtual connections to ATM interface **230**. The originating CCMs also send signaling messages to CCM **250**. The signaling messages identify the destinations for the calls and the selected virtual connections. CCM **250** will have a list of available access connections to the identified destinations. CCM **250** will select the access connections to the destinations from the list. For example, the connection selected by CCM **250** could be a DS0 embedded within a DS3 connected to a LEC. The virtual connections on connection **283** and selected access connections on connection **280** are provided to assignment **240** over link **292**. Assignment **240** provides these assignments to AAL **220**.

ATM interface **230** will demux the cells arriving from connection **283** and provide them to AAL **220**. AAL **220** converts the user information in the cells into the DS0 format. AAL **220** make the conversion so that cells from a particular virtual connection are provided to the assigned DS0 on connection **281**. DS0 interface will convert the DS0s from connection **281** into the appropriate format, such as DS3, for connection **280**. Those skilled in the art are aware of the techniques for muxing and transporting DS0 signals.

From the above discussion, it can be seen that user information for calls can flow from connection **280** to connection **283**, and in the reverse direction from connection **283** to connection **280**. DS0 interface **210** and ATM interface **230** provide user information in their respective formats to AAL **220**. AAL **220** converts the user information between DS0 and ATM formats based on the assignments from assignment **240**. CCM **250** can select the DS0—virtual connection assignments that drive the process.

The ATM Interworking Multiplexer

FIG. **3** shows one embodiment of the mux that is suitable for the present invention, but other muxes that support the requirements of the invention are also applicable. Shown are control interface **300**, OC-3 interface **305**, DS3 interface **310**, DS1 interface **315**, DS0 interface **320**, digital signal processing (DSP) **325**, AAL **330**, and OC-12 interface **335**.

OC-3 interface **305** accepts the OC-3 format and makes the conversion to DS3. DS3 interface **310** accepts the DS3 format and makes the conversion to DS1. DS3 interface **310** can accept DS3s from OC-3 interface **305** or from an external connection. DS1 interface **315** accepts the DS1 format and makes the conversion to DS0. DS1 interface **315** can accept DS1s from DS3 interface **310** or from an external connection. DS0 interface **320** accepts the DS0 format and provides an interface to digital signal processing (DSP) **325**.

DS0 interface **320** is coupled to DSP **325**. DSP **325** is capable of manipulating the user information to improve transmission quality. DSP processing primarily entails echo cancellation, but could include other features as well. As is known, echo cancellation can be required for voice calls. DSP **325** passes the DS0s through echo cancellers. These echo cancellers must be disabled for calls that do not require echo control. Data calls do not require echo cancellation, and the CCM has the ability to recognize data calls that require an echo canceller to be disabled. The CCM will send

a control message to DSP **325** indicating the particular echo canceller that is to be disabled. The CCM selects the echo canceller based on the Circuit Identification Code (CIC) in the signaling it receives from the user. After the data call, the CCM sends a message that causes the particular echo canceller to be enabled again for subsequent voice calls. The above technique of applying echo control is preferred, but other means of implementing echo control instructions from the CCM are also applicable.

In addition to echo control, the CCM and the mux can work to provide other digital signal processing features on a call by call basis. Compression algorithms can be applied, either universally, or on a per call basis. The decibel level could be adjusted for calls form a particular origin or to a particular destination, i.e. where a hearing impaired person may reside. Encryption could be applied on a call-by-call basis based on various criteria like the origination number or the destination number. Stored messages could be plated on the line, DTMF tones could be detected and transmitted on the line. DTMF information might be exchanged with the CCM, or another service platform. Various DSP features could be associated with various call parameters and implemented by the CCM through DSP **325**.

DSP **325** is connected to AAL **330**. AAL **330** operates as described above for an AAL. DS0—virtual connection assignments from control interface **300** are implemented by AAL **330** when converting between the DS0 and ATM formats. Calls with a bit rate greater than 64 kbit/sec. are known as N×64 calls. If desired, AAL **330** can be capable of accepting control messages through control interface **300** from the CCM for N×64 calls. The CCM would instruct AAL **330** to group the DS0s for the call.

The ATM Cross-Connect System

FIG. **4** depicts virtual connections provided by the ATM cross-connect system in a version of the invention, although numerous other techniques for providing virtual connections will be appreciated by one skilled in the art, and the invention contemplates any such system. Shown are virtual connections **410**, **412**, **414**, **416**, **418**, **420**, **422**, **424**, and **426**. These virtual connections are shown interconnecting muxes **1**, **2**, and **3** through cross-connects X and Y. Virtual connections are provisioned in between each mux. Each mux would have a virtual path provisioned through the cross-connect system to every mux. Additional virtual paths could be provisioned between two muxes using diverse physical routes for the sake of redundancy. These virtual paths are designated in the ATM cells by the VPI. The VPIs are designated locally by the cross-connects to be the destination mux. For example, connections **410**, **416**, and **424** are all designated as VP**1** because they terminate at mux **1**. Connections that terminate at mux **2** can be defined locally as VP**2**. On a call entering at mux **1**, the NPA-NXX of the dialed number might be analyzed to select mux **2** as the terminating mux. As such the VPI used on the call would be VP**2**. From mux **1**, VP**2** connects to mux **2**. The VCIs in VP**2** would also be tracked and an available one would be selected. As an alternative to VPI provisioning between muxes, ranges of VCIs may be provisioned between muxes to add granularity below the VPI level.

Additional granularity is required to specify the destination beyond the mux. For example, a mux might be connected to several different destination over several different DS3 trunks. This is illustrated by connections **430**, **432**, and **434** between mux **2** and destinations A, B, and C respectively. On a call through mux **2**, it could be desirable to specify the destination for the call to mux **2** in addition to the VPI/VCI the call will use. This could be done by designating both the VPI/VCI and the destination code in the message from the originating CCM to the terminating CCM. The terminating CCM would then select the DS0 to the destination. This allows the local CCM to select DS0s to a pre-selected destination.

Typically, calls will require a bi-directional voice connection. Conventional voice circuits, such as the DS0, are bi-directional. ATM connections are not typically bi-directional. For this reason, a virtual connection must also be selected to transport user information in the opposite direction—terminating to receiving. This could be done by simply loading all selection tables with the corresponding VPI/VCI to make the connection bi-directional. If only a uni-directional communications path is required, this may be omitted.

Operation Within a Network

FIG. **5** depicts an embodiment of the invention with respect to a specific telecommunications network scenario, although the invention is not limited to this specific scenario. FIG. **5** shows telecommunications system **500**. Shown are user **510**, user **512**, user **514**, user **516**, STP **518**, STP **520**, STP **522**, STP **524**, mux **526**, mux **528**, mux **530**, mux **532**, call/connection manager (CCM) **534**, CCM **536**, CCM **538**, CCM **540**, ATM cross-connect **542**, ATM cross-connect **544**, ATM cross-connect **546**, and Service Control Point (SCP) **550**. The CCMs are designated as "signaling processor" on FIG. **5**. For clarity, the connections and signaling links are not numbered. Except for the SCP, all of these components are described above, and the CCMs are also discussed below. SCPs are well known in the art. An SCP is a processor and database that answers signaling queries to assist in call processing. An example is an "800" routing query between a switch and an SCP.

In operation, user **510** may forward an 800 call to system **500**. User **510** could be connected to mux **526** with a DS3 connection. The 800 call would occupy a DS0 embedded in the DS3 connected to mux **526**. User **510** would send an SS7 Initial Address Message (IAM) through STP **518** to system **500**. STP **520** would be configured to route the IAM to CCM **534**. An IAM contains information such as the dialed number, the caller's number, and the circuit identification code (CIC). The CIC identifies the DS0 used by user **510** for the call.

CCM **534** would process the IAM and identify that the call was an 800 call. After initial call processing, CCM **534** would query SCP **550** for routing instructions. SCP **550** would translate the dialed number based on the 800 subscriber's routing plan. For example, 800 calls from user **510** may be routed to user **512** during business hours, to user **514** at night, and to user **516** on weekends. If the call is placed from user **512** on a weekend, the call would be routed to user **516**. As such, SCP **550** would return the POTS number for user **516** to CCM **534**.

CCM **534** would process the POTS number to select: 1) the VPI/VCI for a virtual connection from mux **526** to mux **530**, 2) the destination point code (DPC) for CCM **538**, and 3) the identification of a trunk group from mux **530** to user **516**. CCM **534** would generate an IAM message to send to CCM **538** and insert the selected information. Since the two muxes define the VPI between them, the originating point code and the destination point code of the IAM can be used

by CCM **538** to identify the selected VPI for the call. The OPC and DPC would be placed in the routing label of the IAM.

The VCI and trunk group ID could be placed in the CIC field of the IAM including the two spare bits. Since 16 bits are available, 256 trunk groups and 256 VCIs are available. These bits should be configured to allocate 256 VCIs to each of the 256 trunk groups that are available for each VPI. The terminating CCM would have to use both the VPI code and the CIC to identify the actual VCI in the cell headers. In other words, between an originating mux and a terminating mux there is one VPI. For that VPI, there are 256 possible trunk groups to connect to on the other side of the mux, and 256 VCIs are allocated for each VPI/trunk group combination. CCM **534** would send the IAM message to CCM **538** through STP **520** and STP **522**. If the IAM is N-ISUP, it could be transported conventionally or over ATM connections by using an SAAL and an ATM layer to encapsulate the message. In the alternative to the above scenario, the VPI, VCI, and trunk group could be identified in a private parameter of the IAM, or they could be delivered in a separate message between the CCMs.

CCM **534** has effectively routed the call for CCM **538**. If N-ISUP is used for the IAM format, the routing label and the CIC are at a fixed location. Because the VPI/VCI and the trunk group to user **516** are coded into the IAM at a fixed location. CCM **538** does not need to parse the entire IAM or perform detailed call processing. CCM **538** only needs to select an available DS0 in the identified trunk group and to select the DPC for user **516**. The service indicator, also at a fixed location of the IAM, could be used to indicate to a terminating CCM that the originating CCM has pre-routed the call, and that call processing need only entail selection of a DS0 and DPC for the identified trunk group. DS0 and DPC selection could be accomplished by a database look-up. Echo control can be handled in a similar manner. CCM **534** handles echo control at the originating side of the call. For echo control at the terminating side, CCM **534** could use the service indicator to indicate that echo control did not need to be handled by CCM **538**. This would be the case for a conventional voice call where an echo canceller is already active at the terminating side. Alternatively, CCM **538** could assess echo control using fixed parts of the IAM and still avoid parsing the entire message. In some embodiments, it may be desirable to have CCM **538** process the IAM in a similar fashion as CCM **534**.

Typically, mux **530** would be connected to user **516** with a DS3 trunk group. CCM **538** would select a DS0 embedded in the DS3 and would send an IAM to user **516** through STP **522** and STP **524**. The CIC of this IAM would indicate that a call was being routed to user **516** over the selected DS0. This CIC would be in conventional 14 bit format with two spare bits. User **516** would process the IAM and complete the call. When the call is answered, user **516** would transmit an answer message (ANM) through STP **524** back to system **500**.

CCM **534** would also send a UDP/IP message to mux **526** instructing it to assemble the user information in the DS0 from user **510** into ATM cells with a cell header identifying the selected VPI/VCI. CCM **538** would send a UDP/IP message to mux **530** instructing it to disassemble ATM cells from the selected VPI/VCI and output the user information to the selected DS0 to user **516**. ATM cross-connect **542** would route ATM cells from mux **526** to ATM cross-connect **544** based on the cell header. Likewise, ATM cross-connect **544** would route these cells to mux **530** based on the cell header. As such, user information for the call would flow from user **510** to user **516** over the DS0 from user **510**, the virtual connection selected by CCM **534**, and the DS0 to user **516** selected by CCM **538**. The muxes would implement the selections of the CCMs.

The call would require that a voice channel be available in both directions. As such, the DS0s and virtual connection would be bi-directional. In the ATM system, this could be accomplished by assigning a reciprocal VPI/VCI in the reverse direction for each VPI/VCI in the forward direction. Cut-through on the receive channel (from the user **516** to the user **510**) would occur after the address complete message (ACM) had been received by system **500**. Cut-through on the transmit channel (from the user **510** to the user **516**) would occur after the answer message (ANM) had been received by system **500**. This could be accomplished by not allowing mux **530** to release any cells for the call until the ANM has been received by system **500**.

If user **510** were to place the call at night, CCM **534** and SCP **550** would determine that user **514** was the destination. Accordingly, a pre-provisioned virtual connection from mux **526** through ATM cross-connect **542** and ATM cross-connect **546** to mux **528** would be selected by CCM **534** for the call. CCM **536** would select the DS0 to user **514**.

If user **510** were to place the call during the day, CCM **534** would determine that user **512** was the destination. Accordingly a pre-provisioned virtual connection from mux **526** through ATM cross-connect **542** and back to mux **526** would be selected for the call. CCM **534** would also select the DS0 to user **512**. In some embodiments, the mux could be designed to cross-connect DS0 to DS0 as well as DS0 to VPI/VCI. In this case, mux **526** would make a DS0 to DS0 connection in response to the message from CCM **534** and the ATM system would not be used.

The Call/Connection Manager (CCM)

FIGS. **6-12** refer to a preferred embodiment of the signaling processor, also known as the CCM, but any processor which supports the requirements stated for the invention would suffice. FIG. **6** depicts a signaling processor suitable for the invention. Signaling processor **600** would typically be separate from the mux, but those skilled in the art appreciate that they could be housed together and coupled in a bus arrangement instead of being coupled by a data or signaling link. Signaling processor **600** may support a single mux or support multiple muxes.

Signaling processor **600** includes Message Transfer Part (MTP) **610**. MTP **610** can be comprised of signaling point software that is known in the art. MTP **610** includes various levels known as MTP 1, MTP 2, and MTP 3. MTP 1 defines the physical and electrical requirements for a signaling link. MTP 2 sits on top of MTP 1 and maintains reliable transport over a signaling link by monitoring status and performing error checks. Together, MTP 1-2 provide reliable transport over an individual link. A device would need MTP 1-2 functionality for each link it uses. MTP 3 sits on top of MTP 2 and provides a routing and management function for the signaling system at large. MTP 3 directs messages to the proper signaling link (actually to the MTP 2 for that link). MTP 3 directs messages to applications using MTP **610** for access to the signaling system. MTP 3 also has a management function which monitors the status of the signaling system and can take appropriate measures to restore service through the system. MTP levels 1-3 correspond to layers 1-3 of the open systems interconnection basic reference model (OSIBRF). MTP **610** could also include Signaling Connection Control Part (SCCP) functions, as well as, TCAP, and

ISUP functional interfaces. In addition, MTP **610** may be equipped with ISUP timers that generate release messages or re-transmit messages where appropriate. If B-ISUP signaling is being used, MTP **610** could also be equipped with B-ISUP capability. All of these elements are known in the art.

Also shown for signaling processor **600** are platform handler **620**, bearer control **630**, message handler **640**, and record handler **650**. MTP **610** could be connected to platform handler **620** by an ethernet interface supporting TCP/IP which transfers signaling messages from MTP **610** to platform handler **620**. Those skilled in the art will recognize other interfaces and protocols which could support these functions in accord with the invention.

Platform handler **620** is a system which accepts ISUP messages from MTP **610** and routes them to message handler **640**. Message handler **640** is a system which exchanges signaling with platform handler **620** and controls the connection and switching requirements for the calls. Bearer control **630** handles bearer capabilities for the call. Record Handler **650** generates call records for back-office systems.

In operation, ISUP messages are routed by MTP **610** to platform handler **620**. Platform handler **620** would route the ISUP messages to message handler **640**. Message handler **640** would process the ISUP information. This might include validation, screening, and retrieving additional data for call processing. Bearer control **630** would implement the bearer capabilities required, such as echo cancellation, through control messages to the appropriate network elements. Message handler **640** would complete call processing. Message handler **640** would generate the appropriate messages to implement the call and pass the messages to platform handler **620** for subsequent transmission to the designated network elements. Message handler **640** would also receive ISUP messages from MTP **610** at the completion of the call. Message handler **640** would process these messages and generate subsequent messages to tear down the call. Record handler **650** would obtain call information from message handler **640** and use this information to generate call records. The call records could be used for billing purposes.

Functional entities are well known in the art. Message handler **640** includes at least the call control function (CCF) and the service switching function (SSF). The CCF establishes and releases call connections, and the SSF recognizes triggers during call processing by the CCF and provides an interface between the CCF and the service control function (SCF). The SCF identifies services and obtains data for the service, and is preferably housed in a remote database, such as an SCP. (As such, the SCF is not shown on FIG. **6**.) Message handler **640** is able to control connections, recognize triggers, and access the SCF in a remote database.

Signaling processor **600** is comprised of hardware and software. Those skilled in the art are aware of various hardware components which can support the requirements of the invention. One example of a such hardware is the FT-Sparc provided by Integrated Micro Products PLC. The FT-sparc could use the Solaris operating system also provided by Integrated Micro Products PLC. MTP **610** could be constructed using commercially available SS7 software interface tools. An example of such tools would be SS7 interface software provided by either Trillium, Inc or by Dale, Gesek, McWilliams, and Sheridan, Inc. Any data storage requirements could be met with conventional database software systems.

Software for platform handler **620**, bearer control **630**, message handler **640**, and record handler **650** could be

produced in the following manner. The Intelligent Network Conceptual Model (INCM) of the ITU-T Q.1200 series could be mapped to Specification Design Language (SDL) of ITU-T Z.200 and Message Sequence Charts (MSC) of ITU-T Z.120. Various detection points and points-in-call in the INCM can be skipped to optimize call processing. The SDL could then be compiled into C or C++ and loaded onto the FT-sparc. The software is primarily comprised of several static processes, instantiated processes (from static processes), and communication channels between the processes. Preferably, the software processes would be partitioned into several operating system tasks. Further requirements for the software design will become apparent in the following discussion.

The Platform Handler

Platform handler **620** is preferred, but is not required as its functions could be handled by MTP **610** and/or message handler **640**. Platform handler **620** has messaging interfaces that exchange, buffer, disassemble, and re-assemble messages for MTP **610**, bearer control **630**, message handler **640**, and record handler **650**. Platform handler **620** could exchange these messages over an ethernet-TCP/IP interface, but any technique for transfer of messages is contemplated by the invention. Platform handler **620** could also check the messages for basic flaws. Should more than one message handler be connected to platform handler **620**, ISUP messages could be allocated to the message handlers based on the SLS of the particular ISUP message. Platform handler **620** also accepts routing instructions from message handler **640** for routing certain ISUP messages to particular select call model processes of message handler **640**. Platform handler **620** is also responsible for managing and monitoring CCM activities. Among these are CCM start-up and shutdown, log-in and log-off of various CCM modules, handling administrative messages (i.e. error, warning, status, etc.) from the CCM modules, and handling messages from network operations such as queries, configuration instructions, and data updates. The connections to the various CCM modules are shown. The connection to network operations is the man machine interface which allows the CCM to be controlled and monitored by either a remote or a local operator. Platform handler **620** has a process which retrieves configuration data from internal tables to initialize and configure the CCM. The CCM modules also have internal tables which are used in conjunction with this procedure.

The Message Handler

FIG. **7** depicts a version of the message handler. External connections have been omitted for the sake of clarity. Message handler **700** is shown and includes ISUP **710**, call manager **720**, feature manager **730**, switching manager **740**, and SCF access manager **750**. The primary function of message handler **700** is to process ISUP messages for calls, generate subsequent messages, and invoke services. As a result of its processing, message handler **700** is able to assign incoming access connections (CICs in SS7) to VPI/VCIs and instruct the mux to provide SVPs and SVCs through an ATM cross-connect system.

ISUP **710** receives generic ISUP messages from the platform handler and converts them into specially formatted ISUP messages using receive **712**. ISUP **710** reverses this process in transmit **714** for messages sent to the platform handler. Receive **712** forwards formatted messages to call manager **720**. ISUP **710** also exchanges local management message with the platform handler.

Call manager **720** could include the functionality specified in the Intelligent Network Call Model (INCM) of ITU-T Q.1214 which encompasses the main functionality of the CCF. Call center **722** receives IAM messages and creates an originating call model process for each IAM. Each originating process is parameterized with data from its particular IAM. Additional origination processes can be created based on the IAM if it is a multi-party call. All of these originating processes are represented by originating processes **724**.

An originating process will typically create a detection point process. All of the detection point processes created are represented by detection point processes **726**. Each originating process will also set-up a call control block containing data for the call. Each origination process will execute through a point-in call to a detection point. When detection points are encountered, and the originating process has not been programmed to skip them, a signal representing the detection point is forwarded to the corresponding detection point process. As stated above, call processing can be streamlined by skipping selected detection points and points-in-all. When an originating process sends a detection point signal to the corresponding detection point process, processing is suspended at the originating process until a response is received from the detection point process.

Detection point processes **726** provides a portion of the SSF and acts as a buffer between the call processes and feature manager **730**. A detection point process analyzes the detection point signal from the origination process to determine if is should be acted on or if it can be ignored. If the processing results in a service request or notification, a corresponding signal is sent to feature manager **730**. Detection point responses from feature manager **730** are forwarded back to the appropriate call process. Once call set-up has been authorized for the originating process, a detection point process will also send a signal to call center **722** to create a terminating process.

These terminating processes are represented by terminating processes **728**. A terminating process creates and interacts with detection point processes **726** much like an originating process. A terminating process also creates a terminating call control block. ISUP information is transferred from the originating process for a call to the terminating process for the call. The platform handler is instructed of the originating and terminating processes so that subsequent ISUP messages related to that call can be transferred directly to the appropriate processes by the platform handler. Both originating and terminating processes have a local database. For example, a termination process might access local data to translate the NPA-NXX of a dialed number into the VPI to a destination mux.

The originating processes and terminating processes also exchange messages with bearer control. Typically, these messages relate to echo canceller and mux control. For calls that pass through two muxes (an originating mux into the ATM network and a terminating mux out of the ATM network), both an origination and termination process is required for each mux—a total of four call processes. The originating process for the originating mux will handle echo cancellation for the origination side of the call. The termination process for the origination mux will handle mapping the incoming DS0 to the VPI/VCI. The termination process for the terminating mux will map the VPI/VCI to an outgoing DS0 and handle echo cancellation for the terminating side of the call. If only one mux is used on the call (in and out of the network at the same mux), only a single origination process and a single termination process is required.

The originating processes and terminating processes also exchange messages with the record handler. Typically, these messages relate to billing and operational measurements. Upon call tear down, the record handler receives the originating and terminating call control blocks for billing purposes. These call control blocks typically would identify the following: the call control block ID, the originating/terminating process ID, the message handler, the originating LEC, the LEC trunk circuit (CIC), the ATM virtual circuit, the ATM virtual path, the caller's number, the dialed number, the translated dialed number, the originating line information, the ANI service class, the selected route, the number of the selected route, the SLS, the OPC, the DPC, the service indicator (SIO), echo cancellation status, reason of release, call status, and pointers to adjacent call control blocks. In addition, the call control block would also contain the various times that signaling messages are received, such the address complete message (ACM), the answer message (ANM), the suspend message (SUS), the resume message (RES), and the release message (REL). Those skilled in the art would be aware of other pertinent data to include.

Call manager **720** communicates with feature manager **730**. Feature manager **730** handles interaction of services for the call. Examples of services would be 800 calls, PCS calls, and VPN calls, but there are many others. Feature manager **730** is comprised of feature center **732** and feature processes **734**. Feature center **732** receives the detection point messages from the detection point processes **726**. Feature center **732** then creates a feature process for each call. These processes are represented by feature processes **734**. The feature process will determine if additional data is needed for the detection point. If so, a signal is sent to switching manager **740**. Responses from switching manager **740** are sent to the appropriate detection point process by the feature process for the call.

In this embodiment, the feature process sends all such service signals to switching manager **740**. In other embodiments, services may be segregated into "IN" and "non-IN" services, the feature process would then have to select between an "IN" switching manager or a "non-IN" switching manager when sending service signals to switching manager **740**.

Switching manager **740** is comprised of switching center **742** and switching processes **744**. Switching manager creates a switching process for each service required on the call. These switching processes are represented by switching processes **744**. A switching process will communicate directly with the associated feature process for the call. The switching process will also interface with the SCF. As stated above, the SCF provides the service processing for the call and is preferably located at a remote database. A typical example of accessing SCF would be to send a TCAP query to a service Control Point (SCP) for an "800" number translation. In order to access the SCF, the switching process will use SCF access manager **750**. SCF access manager **750** is comprised of encoder **752** and decoder **754**. Encoder **752** converts signals from switching processes **744** into the proper format for SCF access. Decoder **754** converts messages from the SCF back into the format for switching processes **744**. SCF access manager **750** would typically access the SCF over standard communications links. One example would be an SS7 link using the TCAP/INAP/ASN.1 protocol specified by the ITU. If SS7 is used, SCF access manager **750** could forward its TCAP messages to the MTP function (MTP **610** of FIG. **6**) for subsequent transfer to an STP and SCP.

From the above discussion, it should be clear that message handler **700** is comprised of static processes identified as "centers" that create specific processes for each call. Once created, these specific call processes communicate directly with one another to accomplish call processing.

Bearer Control and the Record Handler

The following discussion refers to both FIGS. **6** and **7**. Depending on which call segment (originating or terminating) is being processed, the origination process or the termination process will check the user service information data and originating line information to assess the need for echo control. If the call is a data call, a message is sent to bearer control **630**. Based on the CIC, bearer control **630** can select which echo canceller circuit needs to be disabled. A message will be generated to that effect and transmitted over a standard data link, such as UDP/IP, to the pertinent echo control system. If the echo canceller is remote, a T1 link may be desired for transport. As described above, echo control can be implemented by the multiplexer. Once a release (REL) message is received for the call, the echo canceller is re-enabled. On a typical call, this procedure will occur twice. Once for an echo canceller on the originating side of the call, and again for an echo canceller on the terminating side of the call. The CCM that handles the IAM for a particular call segment will control the particular echo cancellers for the segment. An example of an echo control system would be a Tellabs echo canceller controller with ethernet interfaces connected over an asynchronous bus to the echo cancellers. The echo cancellers could be integrated into the muxes.

After a release message on a call, the originating and terminating processes will forward the information in the call control block to record handler **650**. Record handler **650** will use the call control block to create a billing record. The call control block would contain information from the ISUP messages for the call and from CCM processing. From the address complete message (ACM), the call control block would include the routing label, CIC, message type, and cause indicators. From the answer message (ANM), the call control block would include the routing label, CIC, message type, and backward call indicators. From the initial address message (IAM), the call control block would include the routing label, CIC, message type, forward call indicators, user service information, called party number, calling party number, carrier identification, carrier selection information, charge number, generic address, origination line information, original called number, and redirecting number. From the release message (REL), the call control block would include the routing label, CIC, message type, and cause indicators. From the suspend message (SUS) or the pass along message (PAM), the call control block would include the routing label, CIC, and message type. Those skilled in the art are familiar with other pertinent information for a billing record and appreciate that some of this information could be deleted. The billing record will be forwarded by record handler **650** to a billing system over a billing interface. An example of such an interface is an ethernet—FTAM protocol.

Call Processing

SS7 messaging is well known in the art. SS7 ISUP messages contain numerous fields of information. Each message will have a routing label containing a destination point code (DPC), an origination point code (OPC), and a signaling link selection (SLS) which are used primarily for routing the message. Each message contains a circuit identification code (CIC) which identifies the circuit to which the message relates. Each message contains the message type which is used to recognize the message. ISUP messages also contain mandatory parts filled with fixed length data and variable length data, in addition to a part available for optional data. These parts vary from message type to message type depending on the information needed.

The initial address message (IAM) initiates the call and contains call set-up information, such as the dialed number. IAMs are transferred in the calling direction to set up the call. During this process, TCAP messages may be sent to access remote data and processing. When the IAMs have reached the final network element, an address complete message (ACM) is sent in the backward direction to indicate that the required information is available and the called party can be alerted. If the called party answers, an answer message (ANM) is sent in the backward direction indicating that the call/connection will be used. If the calling party hangs up, a release message (REL) is sent to indicate the connection is not being used and can be torn down. If the called party hangs up, a suspend message (SUS) is sent and if the called party reconnects, a resume (RES) message keeps the line open, but if their is no re-connection, a release message (REL) is sent. When the connections are free, release complete messages (RLC) are sent to indicate that the connection can be re-used for another call. Those skilled in the art are aware of other ISUP messages, however, these are the primary ones to be considered.

In the preferred embodiment, call processing deviates from the basic call model recommended by the ITU, although strict adherence to the model could be achieved in other embodiments. FIGS. **8**-**16** depict message sequence charts for the call processing in one embodiment. Message sequence charts are known in the art, and are a recognized format to depict call processing. At the top of the chart, the basic elements of the CCM are shown—the platform handler, the message handler, the bearer control, and the record handler. The blocks below the message handler indicate the processes for the message handler. Further specification at the process level for the platform handler, the bearer control, and the record handler is not required for this discussion. The charts are read down in a chronological sequence. Blocks indicate tasks performed by the process named above. Arrows indicate messages exchanged between the processes or the creation of a new process by an existing process.

The sequence starts on FIG. **8** with an ISUP message at the platform handler. The platform handler forwards the message to the ISUP receive process of the message handler. If the ISUP message is an IAM, the ISUP receive process forwards the IAM to the call center. The call center had been in the "origination null" point-in-call, but the IAM causes the call center to create an originating call process parameterized with contents of the IAM. The originating process then executes through the "authorize origination attempt" point-in-call. This typically entails ANI validation in a look-up table, but prior to the look-up, call information is checked to determine if ANI validation is required. For particular types of calls, i.e. "800" calls, origination is authorized without ANI validation.

Once origination has been authorized, the originating process creates a detection point process and transmits a signal to the detection point process that origination has been authorized. The detection point process returns a message instructing the origination process to execute through the "analyze information" point-in-call, although a

detection point could be programmed at this point if desired. Continuing on to FIG. **9**, "Analyze information" typically entails verifying that the dialed number is legitimate and checking call information for any applicable services. A few examples of a services are "800" and PCS. In this example, no services are required for the call—the call is a typical POTS call. Once the analysis has been accomplished, the originating process sends a "analyzed information" message to the detection point process. Typically, the detection point process returns a "resume" message to the originating process, but detection points could be programmed here if desired.

The resume message causes the origination process to execute through the "routing and alerting" point-in-call. This typically entails translating the dialed number to select a destination address. For example, the NPA-NXX of the dialed number could be used in a look-up table to yield the address of the terminating mux and the device that should receive the call from the mux. The origination process will also send a message to the call center to create an terminating call process. The terminating call process is provided with the identity of the originating process. The terminating process also creates a detection point process to handle the detection points it encounters. For purposes of clarity, this is indicated along the same line as the originating process detection point, although it should be understood that each process communicates with its corresponding detection point.

Continuing on to FIG. **10**, the terminating process executes through the "authorize termination attempt" point-in-call. This typically entails verifying that an ATM connection to another mux can be attempted. For example, the CCM and the mux at the terminating end must be operational to handle the call. Once termination is authorized, an authorized message is sent to the detection point process, which returns a resume message to the termination manager (unless a detection point is programmed into the detection point process.)

The terminating process will then execute through the "select facility and present call" point-in-call. This typically entails selecting the actual VPI/VCI and outbound connection for the call. The destination has already been specified during the "routing" point-in-all, so the VPI/VCI and point codes can be looked-up accordingly. The terminating process will then send a message to bearer control requesting mux control. Bearer control would then create a message for the originating mux identifying the connections and devices relevant to the call. Bearer control would respond that mux control was handled. Continuing on to FIG. **11**, the terminating process would then construct an IAM for transmission to the downstream CCM at the terminating mux. As discussed above, this message could be coded such that the downstream CCM could skip detailed call processing. The IAM would be provided to the ISUP sender and a formatted IAM would be provided to the platform handler for subsequent transmission to the downstream CCM.

On a typical call, the next message that would be received by the CCM that is related to the call would be an Address Complete Message (ACM) signifying that the terminating end of the call had the information required to complete the call. This would be the case if the downstream-terminating CCM received the above-mentioned IAM, selected the actual DS0, and sent a subsequent IAM to the external device. As mentioned above, the specially coded IAM would cause the terminating CCM to merely select the outbound DS0, notify the terminating mux, and generate the IAM to send to the external connection. The external device would send an ACM back to the terminating CCM which would pass on an ACM to the originating CCM. These procedures at the terminating CCM are not depicted in the message sequence chart. The message sequence chart continues with the ACM arriving at the originating CCM.

The ISUP receive process would forward the ACM to the terminating process. The terminating process would execute through the "alerting" point-in-call and would send ACM information to the originating process, which would also execute through the "alerting" point-in-call. Alerting entails alerting the users that a connection is available—i.e. ringing a telephone. Typically, no specific activity is required for "alerting", but detection points could be inserted into the process if desired. The originating process would forward an ACM to the ISUP sender which would provide a formatted ACM to the platform handler for subsequent transmission to devices at the origination side of the call.

On the typical call, an Answer Message (ANM) will be transferred from the terminating side of the call to the origination side of the call when the called party answers the phone. The ANM is received by the platform handler and forwarded to the ISUP receive process which forwards its version to the terminating process. Continuing on to FIG. **12**, the terminating process executes though the "active" point-in-call and sends ANM information to the detection point process. Typically, the detection point process will return a resume message, although detection points could be included here if desired. The terminating process also sends a mux control message to bearer control to facilitate cut-through on the call at the mux. A acknowledgment response is sent back to the terminating process from bearer control. The terminating process also sends ANM information to the originating manager, which also executes through the "active" point-in-call. The originating process also sends an answer message to the detection point process and a partial call control block to the record handler. Typically, the detection point process will send a resume message back to the origination process. The originating process would forward an ANM to the ISUP sender which would provide a formatted ANM to the platform handler for subsequent transmission to devices at the origination side of the call. At this point, the call is in progress.

The message sequence continues with the receipt of a release message (REL) after the caller or called party hang up. As stated above, if the called party hangs up, a suspend message (SUS) is sent before the call is released, but if the caller hangs up, only an REL is sent. For clarity, the chart picks up with an REL arriving from the terminating side of the call. The REL is received by the platform handler and transferred to the ISUP receive process, which provides its version of the message to the terminating process. (Had the REL been from the originating side, it would have been provided to the originating process.) The terminating process executes through the "disconnect" point-in-call. Continuing on FIG. **13**, the terminating process sends REL information to the originating process. The originating process would forward an REL to the ISUP sender which would provide a formatted REL to the platform handler for subsequent transmission to devices at the origination side of the call. In response to the REL, the terminating process will forward a Release Complete Message (RLC) to the ISUP sender which would provide a formatted RLC to the platform handler for subsequent transmission to the device that sent the REL. The RLC acknowledges the REL and signifies that the call connections may be torn down and re-used. The terminating process also sends a mux control message to bearer control to cause the relevant VPI/VCI to be torn

down, and receives an acknowledgment response from bearer control. The originating process sends an echo control message to bearer control to ensure that the relevant echo canceller is enabled and receives and acknowledgment response from bearer control.

The next message will typically be an RLC in response to the REL sent to the originating side of the call. The RLC is received by the platform handler and forwarded to the ISUP receive process. ISUP receive provides its version of the message to the originating process. This causes the originating process to forward its final call control block to the record handler. The originating process also provides RLC information to the terminating process. This causes the terminating process to send its final call control block to the record handler. The record handler responds to each process with an acknowledgment response. Continuing on to FIG. **14**, tear down messages are sent by the originating process and the terminating process to their respective detection point processes. Typically, no detection points will be programmed and the originating process, the terminating process, and the detection point processes will terminate and be cleared from the CCM.

FIG. **15** depicts a modified excerpt from message sequence chart of FIG. **9**. The modification is for a data call that requires the echo cancellation on the connection to be disabled. As shown, the message sequence chart picks up call processing at the "routing and alerting" point-in-call. Part of the execution through the "routing and alerting" point-in-call includes a check of IAM information to determine if echo cancellation should be disabled. If so, the originating process sends an echo control message to bearer control. Bearer control will send a message disabling the appropriate echo canceller. Bearer control also sends an acknowledgment response back to the originating process. Subsequent call processing continues as discussed above and the echo canceller is re-enabled after the call.

FIG. **16** also depicts a modified excerpt from the message sequence charts above. The modification is for a call that requires services. Services might include N00 or VPN calls, but many other services are known. In this embodiment, an SCP is accessed to provide information to implement the service. As shown, call processing picks up where the detection point process for either the originating process or the terminating process analyzes a detection point and determines that a service is required. Typically, this is done by examining the dialed number and the caller's number. Those skilled in the art are aware of how services can be determined from call information.

If it is determined that a service should be applied to the call, the detection point process sends detection point message to the feature center that causes the feature center to create an feature process. The feature process will be perameterized with call information and will send a detection point message to the switching center. In some embodiments, the feature process will choose between "IN" services and "non-IN" services and send the detection point message to the corresponding switching center. Upon receiving the message, the switching center creates a service process for each service to be applied to call. The service process formulates a request for service information and forwards it to the encoder of the SCF access manager. The encoder produces a TCAP message and transmits it over the appropriate link to a remote SCF, (possibly through the platform handler and/or the MTP interface). The remote SCF will return a response to the decoder. The response is formatted for the service process and sent to it. The service process takes the response and formulates an analyze information message that is transferred back through the feature process to the detection point process. The detection point process transfers the analyze information message to the applicable originating or terminating process. Subsequent call processing remains the same as discussed above. At call tear down, the feature process and the switching process are cleared from the CCM.

An example of the above scenario would be for an "800" call. The CCM would recognize that the "800" in the called number required service application. As a result, it would generate and transmit TCAP query to an SCP requesting an "800" translation. The SCP would process the query and translate the "800" number into a POTS number. The SCP would return the POTS number to the requesting CCM. The CCM would then process the POTS number as it would for a standard POTS call.

In some embodiments, the CCM processes SS7 signaling messages to accomplish the following functions: validation, routing, billing, and echo cancellation. SS7 messages are well known in the art. The following sections discuss SS7 processing, but those skilled in the art will recognize variations that are also contemplated by the invention. In SS7, the routing labels of the messages are used to correlate messages to calls. Contemporaneous messages with the same OPC, DPC, and CIC relate to the same call.

To validate a call, the routing label of messages should be checked. The Service Indicator should be checked to distinguish between an incoming message from outside of the network or a message from a network CCM. The Destination Point Code is screened to ensure the destination of the SS7 message is actually destined for the CCM. The Originating Point Code is screened to ensure the originating point code is allowed in the CCM. The Message Type is screened to ensure that the type of message is allowed in the CCM and that there are no protocol violations associated with the message.

Both the Circuit Reservation Message (CRM) and the IAM should have the Satellite Indicator screened to ensure that the limit on the number of Satellites in a circuit has not been exceeded. This will be on a trunk group by trunk group basis. The REL automatic congestion level will be screened to see if congestion arises. The CCM should then control calls to the associated network elements until the congestion abates. For non-call associated messages, the circuit group supervision message type indicator will be screened to compare the state of the circuits with the instructions incoming in the messages.

The IAM will receive additional treatment for validation. Information Transfer Capability will be screened to ensure that the connection for the call is capable of handling the transfer rate requested. The Coding Standard will be screened to ensure that the standard is coded 00. All others will be rejected. Transfer Mode will be screened to ensure that the mode is coded 00 for 64 Kbit/second calls. User Layer Protocol ID and the Rate field will be screened to ensure that there is no rate adaptation required for the call. The Network ID Plans and Digits, will be screened to ensure that the carrier identification field and the transit network carrier identification field is in the correct format. The Circuit Code will be screened to allow callers with the correct means of dialing to access the network.

The CCM will check the Hop Counter in the IAM to determine if it has reached its limit as set by this field (range 10 to 20 with a default of 20). If it has not, the CCM will increment the parameter. If it has reached the determined count, the CCM will send a release message back with a cause of "exchange routing error" to tell the preceding

switch that the IAM has reached its limit in hops. If this field is left blank, the CCM will not increment the counter parameter and pass the IAM unchanged.

The IAM Called Party Number field should be handled as follows for validation. Nature of Address will tell the CCM what type of number was dialed for the called number. The screening of this field will be for a non-NPA number. If that occurs, the CCM will need to add the NPA from the Trunk Group to the call control block. Numbering Plan will be screened to check what type of plan the incoming called party number uses. The only allowable plans are Unknown and ISDN numbering plans. All others should be disallowed. Digits Field will be screened for the number of digits using the Nature of Number, Odd/Even, and Digits Fields to determine the correct number of digits.

The IAM Calling Party Number and Charge Number fields should be handled as follows for validation. Nature of Address will be screened to ensure that the calling party's number is in the proper format. Presentation Allowed/Restricted will be screened to check for N00 calling. Numbering Plan will be checked to ensure that the numbering plan is set at either unknown or ISDN numbering plan. Digits Field will be checked to ensure that there is enough digits for an ANI that can be billed. These digits will be validated in an ANI table for call authorization.

Routing is primarily accomplished by processing the IAM. Called Party Number—Nature of Address, Digits—this will tell the CCM what type of call this is. It will differentiate 0+, test calls, and International numbers from normal 1+ calls. The Calling Party's Category tells the CCM that the call is a test call with different routing than a normal call. The Carrier Identification Plan will be used to determine if the CCM receives the Carrier Identification Code of another carrier, since the CCM may wish to route the call based on the subscribers choice of carriers. The IAM Carrier Selection Information is used to route the call based on whether the subscriber was presubscribed or dialed the carrier access number. The IAM Originating Line Information will enable the CCM to route based on what type of originating line is being used for this call. An example is if a payphone makes a 1+ call, the CCM will be able to route the call directly to an operator for billing arrangements. The IAM Transit Network Selection fields will indicate the Carrier Identification Code of the International Carrier that is requested by the subscriber, so the CCM can route the international call to the correct switch. The Circuit Code will tell the CCM how the code was dialed. If the subscriber dialed an access code for a different international carrier, the CCM could route the call to an operator center for processing.

The IAM Called Party Number fields are handled as follows for routing. Nature of Address Indicator tells what type of call is being requested. This will include 0+ and 0− calls, international calls (operator and non operator calls), cut through, and 950 types of calls. With this information, the CCM can route the call directly to the international gateway or operator center without looking at the rest of the message. For normal 1+ calls, the Odd/Even field will be used with the digits fields to determine the number of digits. Numbering Plan field will be used to route calls differently if it has a "Private Numbering Plan" value in the field. Digits Field will be the digits that will be used to route the call through the network using table look-ups. Typically, the digits field houses the dialed number.

Billing will be based on the Call Control Blocks (CCBs) created by the call processes. A portion of these records are transferred from messages received by the CCM. The CCBs are discussed above. When the Calling Party Number is present in the IAM and there is no Charge Number present, the Calling Party Number is used to bill the call. If the Charge Number is present in the same message, then the Charge Number will be used for billing instead of the Calling Party Number. Various messages need to be tracked to measure the duration of the call. These include the IAM, ACM, ANM, SUS, REL, and RLC. The causes associated with these messages should also be considered.

As to echo control, messages should be examined to determine if either side of the call—originating or terminating—has already handled echo control. This can be done by looking at the Echo Suppresser Indicator in the Nature of Connection Indicators Parameter of the CRM or the IAM, or the Echo Control Device Indicator in the Backward Call Indicators Parameter of the ACM or the Call Progress Message (CPM). If no echo control has been provided, the CCM will implement echo control depending on the Information Transfer Capability in the User Service Indicator Parameter of the IAM.

The invention allows switching over an ATM fabric on a call by call basis. This allows efficient high capacity virtual connections to be exploited. Advantageously, the invention does not require signaling capability in an ATM switch. The invention does not require call processing capability in an ATM switch. This enables networks to implement ATM switching without these sophisticated ATM switches that support high volumes of calls. It also avoids the cost of these switches. The invention fully supports voice traffic and non-voice traffic. The invention supports services, such as N00, VPN, personal/terminal mobility, and voice messaging without requiring the service capability in an ATM switch. Relying on ATM cross-connects is advantageous because ATM cross-connects are farther advanced than ATM switches, and the cross-connects require less administrative support.

Those skilled in the art will appreciate that variations from the specific embodiments disclosed above are contemplated by the invention. The invention should not be restricted to the above embodiments, but should be measured by the following claims.

We claim:

1. A method of operating a communication system, the method comprising:

receiving telecommunication signaling for calls into a signaling processor, and responsively on a call-by-call basis, selecting routing information based on the telecommunication signaling and transferring control messages indicating the routing information; and

receiving the control messages and user communications for the calls into a communication unit, and responsively on the call-by-call basis, converting the user communications from a first communication format into a second communication format having headers that include the routing information selected by the signaling processor and transferring the user communications in the second communication format.

2. The method of claim **1** wherein the signaling processor is external to telecommunication switches.

3. The method of claim **1** wherein the user communications comprise voice communications.

4. The method of claim **1** further comprising transferring the control messages from the signaling processor to the communication unit over a bus.

5. The method of claim **1** wherein the telecommunication signaling comprises signaling system seven initial address messages.

6. The method of claim **1** further comprising:

in the signaling processor, selecting echo control based on the telecommunication signaling, wherein the control messages indicate the echo control; and

in the communication unit, controlling echo in the user communications based on the echo control selected by the signaling processor.

7. The method of claim **1** further comprising:

in the signaling processor, selecting encryption based on the telecommunication signaling, wherein the control messages indicate the encryption; and

in the communication unit, encrypting the user communications based on the encryption selected by the signaling processor.

8. The method of claim **1** further comprising:

in the signaling processor, selecting compression based on the telecommunication signaling, wherein the control messages indicate the compression; and

in the communication unit, compressing the user communications based on the compression selected by the signaling processor.

9. The method of claim **1** further comprising:

in the signaling processor, selecting DTMF tone detection based on the telecommunication signaling, wherein the control messages indicate the DTMF tone detection; and

in the communication unit, detecting DTMF tones in the user communications based on the DTMF tone detection selected by the signaling processor.

10. The method of claim **1** further comprising:

in the signaling processor, selecting user messages based on the telecommunication signaling, wherein the control messages indicate the user messages; and

in the communication unit, playing the user messages selected by the signaling processor.

11. A communication system comprising:

a signaling processor receives telecommunication signaling for calls, and responsively on a call-by-call basis, selects routing information based on the telecommunication signaling and transfers control messages indicating the routing information; and

a communication unit receives the control messages and user communications for the calls, and responsively on the call-by-call basis, converts the user communications from a first communication format into a second communication format having headers that include the routing information selected by the signaling processor and transfers the user communications in the second communication format.

12. The communication system of claim **11** wherein the signaling processor is external to telecommunication switches.

13. The communication system of claim **11** wherein the user communications comprise voice communications.

14. The communication system of claim **11** further comprising a bus transfers the control messages from the signaling processor to the communication unit.

15. The communication system of claim **11** wherein the telecommunication signaling comprises signaling system seven initial address messages.

16. The communication system of claim **11** wherein:

the signaling processor is selects echo control based on the telecommunication signaling, wherein the control messages indicate the echo control; and

the communication unit controls echo in the user communications based on the echo control selected by the signaling processor.

17. The communication system of claim **11** wherein:

the signaling processor selects encryption based on the telecommunication signaling, wherein the control messages indicate the encryption; and

the communication unit encrypts the user communications based on the encryption selected by the signaling processor.

18. The communication system of claim **11** wherein:

the signaling processor selects compression based on the telecommunication signaling, wherein the control messages indicate the compression; and

the communication unit compresses the user communications based on the compression selected by the signaling processor.

19. The communication system of claim **11** wherein:

the signaling processor selects DTMF tone detection based on the telecommunication signaling, wherein the control messages indicate the DTMF tone detection; and

the communication unit detects DTMF tones in the user communications based on the DTMF tone detection selected by the signaling processor.

20. The communication system of claim **11** wherein:

the signaling processor selects user messages based on the telecommunication signaling, wherein the control messages indicate the user messages; and

the communication unit plays the user messages selected by the signaling processor.

* * * * *

EXHIBIT L

US007324534B2

(12) **United States Patent**
Christie et al.

(10) **Patent No.: US 7,324,534 B2**
(45) **Date of Patent: *Jan. 29, 2008**

(54) **BROADBAND TELECOMMUNICATIONS SYSTEM INTERFACE**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 816 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **10/682,013**

(22) Filed: **Oct. 9, 2003**
(Under 37 CFR 1.47)

(65) **Prior Publication Data**

US 2004/0085975 A1 May 6, 2004

Related U.S. Application Data

(63) Continuation of application No. 10/237,759, filed on Sep. 9, 2002, now Pat. No. 6,667,982, which is a continuation of application No. 09/800,698, filed on Mar. 7, 2001, now Pat. No. 6,470,009, which is a continuation of application No. 09/413,734, filed on Oct. 6, 1999, now Pat. No. 6,304,580, which is a continuation of application No. 08/755,438, filed on Nov. 22, 1996, now Pat. No. 6,023,474.

(51) **Int. Cl.**
H04L 12/28 (2006.01)
H04L 12/56 (2006.01)

(52) **U.S. Cl.** **370/410**; 370/467

(58) **Field of Classification Search** 370/351, 370/356, 389, 400, 410, 465, 466, 467, 395.1, 370/396, 397, 398, 399, 395.2
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,491,945 A 1/1985 Turner

(Continued)

FOREIGN PATENT DOCUMENTS

EP 0439098 7/1991

(Continued)

OTHER PUBLICATIONS

Hiroshi Ishii and Masatoshi Kawarasaki; B-ISDN Signalling Protocol Capabilities; NTT Telecommunication Networks Laboratories; 1989; pp. 41.2.1-41.2.5.

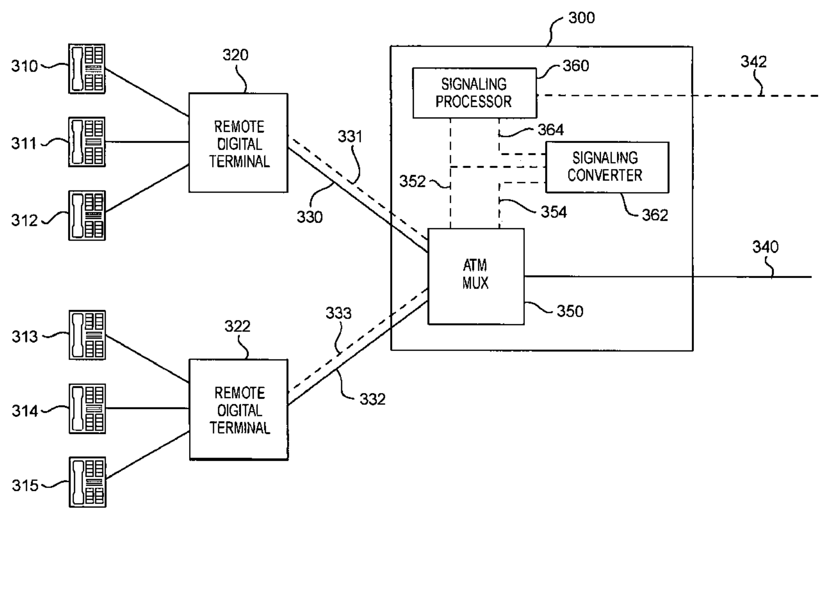
(Continued)

Primary Examiner—Ajit Patel

(57) **ABSTRACT**

The invention is a system for interfacing a GR-303 system with a broadband system. The broadband system can be an ATM system. The invention can process the GR-303 signaling to select ATM connections and then interwork the GR-303 connections with the selected ATM connections. The invention can interwork GR-303 signaling and SS7 signaling. The invention can also process SS7 signaling to select GR-303 connections and then interwork ATM connections with the selected GR-303 connections.

20 Claims, 18 Drawing Sheets



U.S. PATENT DOCUMENTS

4,683,584 A 7/1987 Chang et al.
4,686,669 A 8/1987 Chang
4,686,701 A 8/1987 Ahmad et al.
4,720,850 A 1/1988 Oberlander et al.
4,730,312 A 3/1988 Johnson et al.
4,736,364 A 4/1988 Basso et al.
4,748,658 A 5/1988 Gopal et al.
4,757,526 A 7/1988 Foster et al.
4,763,317 A 8/1988 Lehman et al.
4,853,955 A 8/1989 Thorn et al.
4,970,721 A 11/1990 Aczel et al.
4,991,169 A 2/1991 Davis et al.
4,991,172 A 2/1991 Cidon et al.
5,003,584 A 3/1991 Benyacar et al.
5,029,199 A 7/1991 Jones et al.
5,048,081 A 9/1991 Gavaras et al.
5,051,983 A 9/1991 Kammerl
5,084,816 A 1/1992 Boese et al.
5,089,954 A 2/1992 Rago
5,115,426 A 5/1992 Spanke
5,115,427 A 5/1992 Johnson, Jr. et al.
5,185,743 A 2/1993 Murayama et al.
5,204,857 A 4/1993 Obara
5,251,255 A 10/1993 Epley
5,258,979 A 11/1993 Oomuro et al.
5,268,895 A 12/1993 Topper
5,271,010 A 12/1993 Miyake et al.
5,274,635 A 12/1993 Rahman et al.
5,274,698 A 12/1993 Jang
5,278,972 A 1/1994 Baker et al.
5,282,244 A 1/1994 Fuller et al.
5,289,472 A 2/1994 Cho
5,291,492 A 3/1994 Andrews et al.
5,297,147 A 3/1994 Shimokasa
5,327,421 A 7/1994 Hiller et al.
5,339,318 A 8/1994 Tanaka et al.
5,345,443 A 9/1994 D'Ambrogio et al.
5,345,445 A 9/1994 Hiller et al.
5,345,446 A 9/1994 Hiller et al.
5,363,433 A 11/1994 Isono
5,375,124 A 12/1994 D'Ambrogio et al.
5,377,186 A 12/1994 Wegner et al.
5,392,402 A 2/1995 Robrock, II
5,394,463 A 2/1995 Fischell et al.
5,414,701 A 5/1995 Shtayer et al.
5,420,858 A 5/1995 Marshall et al.
5,422,882 A 6/1995 Hiller et al.
5,425,090 A 6/1995 Orriss
5,428,609 A 6/1995 Eng et al.
5,434,852 A 7/1995 La Porta et al.
5,434,981 A 7/1995 Lenihan et al.
5,438,527 A 8/1995 Feldbaumer et al.
5,438,570 A 8/1995 Karras et al.
5,440,563 A 8/1995 Isidoro et al.
5,440,626 A 8/1995 Boyle et al.
5,444,713 A 8/1995 Backaus et al.
5,452,297 A 9/1995 Hiller et al.
5,452,350 A 9/1995 Reynolds et al.
5,457,684 A 10/1995 Bharucha et al.
5,459,722 A 10/1995 Sherif
5,461,669 A 10/1995 Vilain
5,469,501 A 11/1995 Otsuka
5,473,677 A 12/1995 D'Amato et al.
5,473,679 A 12/1995 La Porta et al.
5,483,527 A 1/1996 Doshi et al.
5,485,455 A 1/1996 Dobbins et al.
5,495,484 A 2/1996 Self et al.
5,497,373 A 3/1996 Hulen et al.
5,506,894 A 4/1996 Billings et al.
5,509,010 A 4/1996 La Porta et al.
5,519,690 A 5/1996 Suzuka et al.
5,519,707 A 5/1996 Subramanian et al.
5,530,724 A 6/1996 Abrams et al.
5,533,115 A 7/1996 Hollenbach et al.
5,537,461 A 7/1996 Bridges et al.
5,541,917 A 7/1996 Farris
5,544,163 A 8/1996 Madonna
5,550,834 A 8/1996 D'Ambrogio et al.
5,550,914 A 8/1996 Clarke et al.
5,563,939 A 10/1996 La Porta et al.
5,566,173 A 10/1996 Steinbrecher
5,568,475 A 10/1996 Doshi et al.
5,577,037 A 11/1996 Takatori et al.
5,579,311 A 11/1996 Chopping et al.
5,586,177 A 12/1996 Farris et al.
5,590,133 A 12/1996 Billström et al.
5,592,477 A 1/1997 Farris et al.
5,600,643 A 2/1997 Robrock, II
5,610,977 A 3/1997 Williams et al.
5,619,561 A 4/1997 Reese
5,623,491 A 4/1997 Skoog
5,635,980 A 6/1997 Lin et al.
5,636,261 A 6/1997 Fils
5,640,446 A 6/1997 Everett et al.
5,666,399 A 9/1997 Bales et al.
5,673,262 A 9/1997 Shimizu
5,684,792 A 11/1997 Ishihara
5,689,550 A 11/1997 Garson et al.
5,689,555 A 11/1997 Sonnenberg
5,701,301 A 12/1997 Weisser, Jr.
5,703,876 A 12/1997 Christie
5,703,880 A 12/1997 Miura
5,706,286 A 1/1998 Reiman et al.
5,710,769 A 1/1998 Anderson et al.
5,715,239 A 2/1998 Hyodo et al.
5,745,553 A 4/1998 Mirville et al.
5,751,706 A 5/1998 Land et al.
5,765,108 A 6/1998 Martin et al.
5,774,530 A 6/1998 Montgomery et al.
5,774,675 A 6/1998 Uchida
5,784,371 A 7/1998 Iwai
5,793,765 A 8/1998 Boer et al.
5,793,857 A 8/1998 Barnes et al.
5,802,045 A 9/1998 Kos et al.
5,825,780 A 10/1998 Christie
5,828,666 A * 10/1998 Focsaneanu et al. 370/389
5,850,391 A 12/1998 Essigmann
5,862,334 A 1/1999 Schwartz et al.
5,867,495 A 2/1999 Elliott et al.
5,867,562 A 2/1999 Scherer
5,867,571 A 2/1999 Borchering
5,872,779 A 2/1999 Vaudreuil
5,872,785 A 2/1999 Kienberger
5,884,262 A 3/1999 Wise et al.
5,892,764 A 4/1999 Riemann et al.
5,915,009 A 6/1999 Williams et al.
5,917,815 A 6/1999 Byers et al.
5,926,464 A 7/1999 Fraser
5,940,393 A 8/1999 Duree et al.
5,940,491 A 8/1999 Anderson et al.
5,940,492 A 8/1999 Galloway et al.
5,949,791 A 9/1999 Byers et al.
5,949,871 A 9/1999 Kabay et al.
5,956,334 A 9/1999 Chu et al.
RE36,416 E 11/1999 Szlam et al.
5,991,301 A 11/1999 Christie
5,999,525 A 12/1999 Krishnaswamy et al.
5,999,594 A 12/1999 Mizoguchi et al.
6,014,378 A 1/2000 Christie et al.
6,026,091 A 2/2000 Christie et al.
6,031,840 A 2/2000 Christie et al.
6,034,950 A 3/2000 Sauer et al.
6,034,972 A 3/2000 Ward et al.
6,038,218 A 3/2000 Otsuka et al.

6,069,890	A	5/2000	White et al.	
6,088,749	A	7/2000	Hebert et al.	
6,137,800	A	10/2000	Wiley et al.	
6,175,574	B1	1/2001	Lewis	
6,181,703	B1	1/2001	Christie et al.	
6,324,179	B1	11/2001	Doshi et al.	
6,327,270	B1	12/2001	Christie et al.	
6,385,193	B1 *	5/2002	Civanlar et al.	370/352
6,487,200	B1	11/2002	Fraser	
6,546,003	B1	4/2003	Farris	
6,546,442	B1	4/2003	Davis et al.	
6,847,611	B1	1/2005	Chase et al.	
2004/0174880	A1 *	9/2004	White et al.	370/395.3
2004/0193329	A1	9/2004	Ransom et al.	
2006/0023676	A1	2/2006	Whitmore et al.	

FOREIGN PATENT DOCUMENTS

EP	0 488 399	6/1992
EP	0935856	8/1999
HU	71152	11/1995
JP	1013534	1/1989
JP	1300738	12/1989
JP	2215247	8/1990
JP	4180324	6/1992
JP	4196635	7/1992
JP	5327751	12/1993
JP	6006320	1/1994
JP	6209365	7/1994
JP	7177061	7/1995
JP	7250099	9/1995
JP	8149137	6/1996
WO	WO9214321	8/1992

OTHER PUBLICATIONS

Kuribayashi, Shin-Ichi; Advanced Signaling Protocol for Broadband ISDN Services; Electronics and Communications in Japan; Part 1, vol. 78, No. 1, pp. 1-12.

Hungarian office action dated Jun. 23, 1999 citing Hungarian patent No. HU170127 for Hungarian Application No. P9900232; 2 pages.

Russian office action dated Apr. 22, 2002 citing Russian patent Nos. RU2013011 and RU2007880 for Russian Application No. 99112956; 6 pages.

Manu Bahl, et al.; “The Evolving Intelligent Interexchange Network—An SS7 Perspective,” Proceedings of the IEEE; Apr. 1992; pp. 637-643; vol. 80, No. 4.

IBM International Technical Support Organization; “Networking BroadBand Services (NBBS) Architecture Tutorial;” Jun. 1995; 248 pages; First Edition; Research Triangle Park, North Carolina, USA.

David J. Wright; “Voice over ATM: An Evaluation of Network Architecture Alternatives;” IEEE Network; Sep./Oct. 1996; pp. 22-27.

* cited by examiner

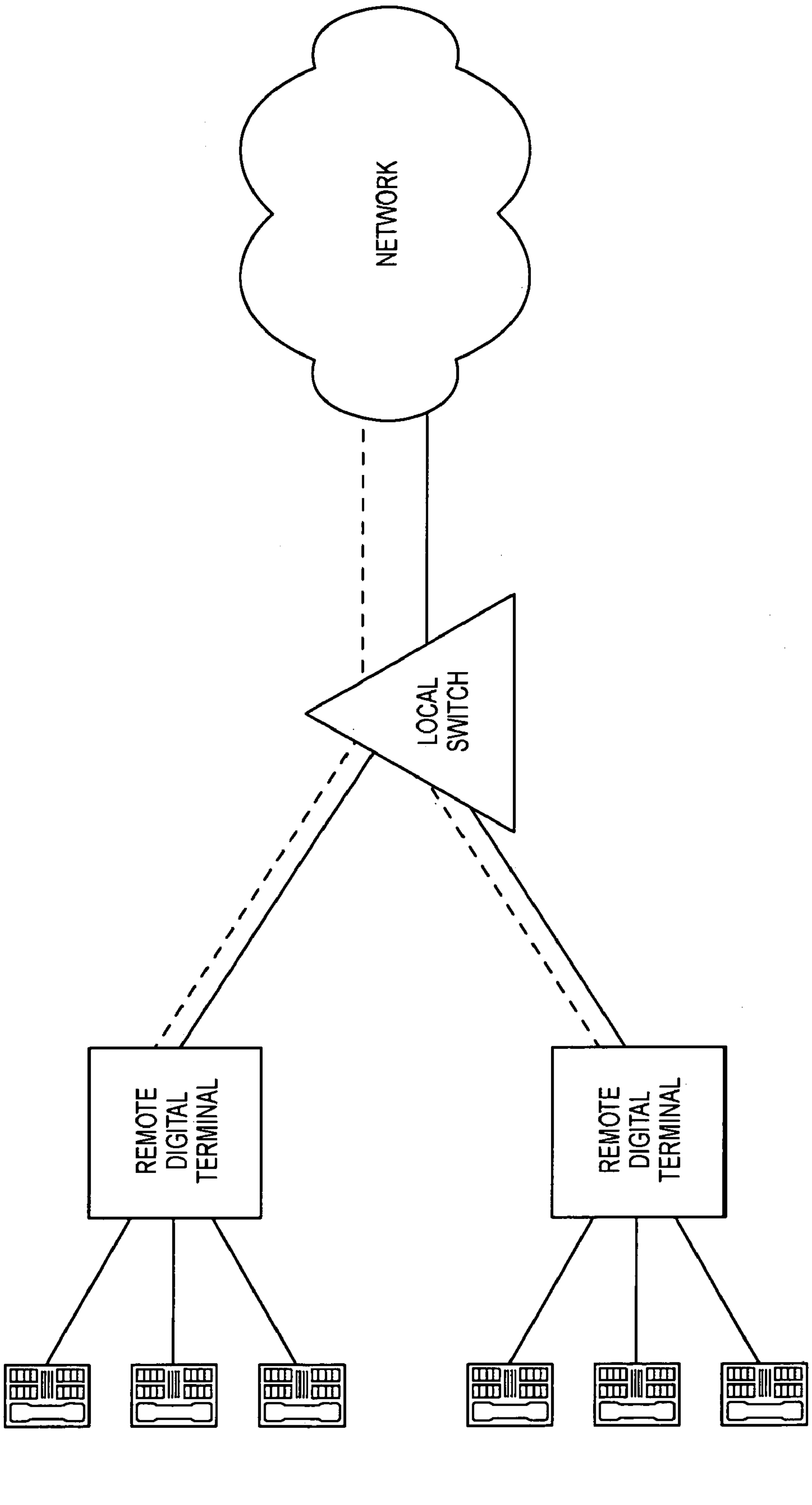


FIG. 1
PRIOR ART

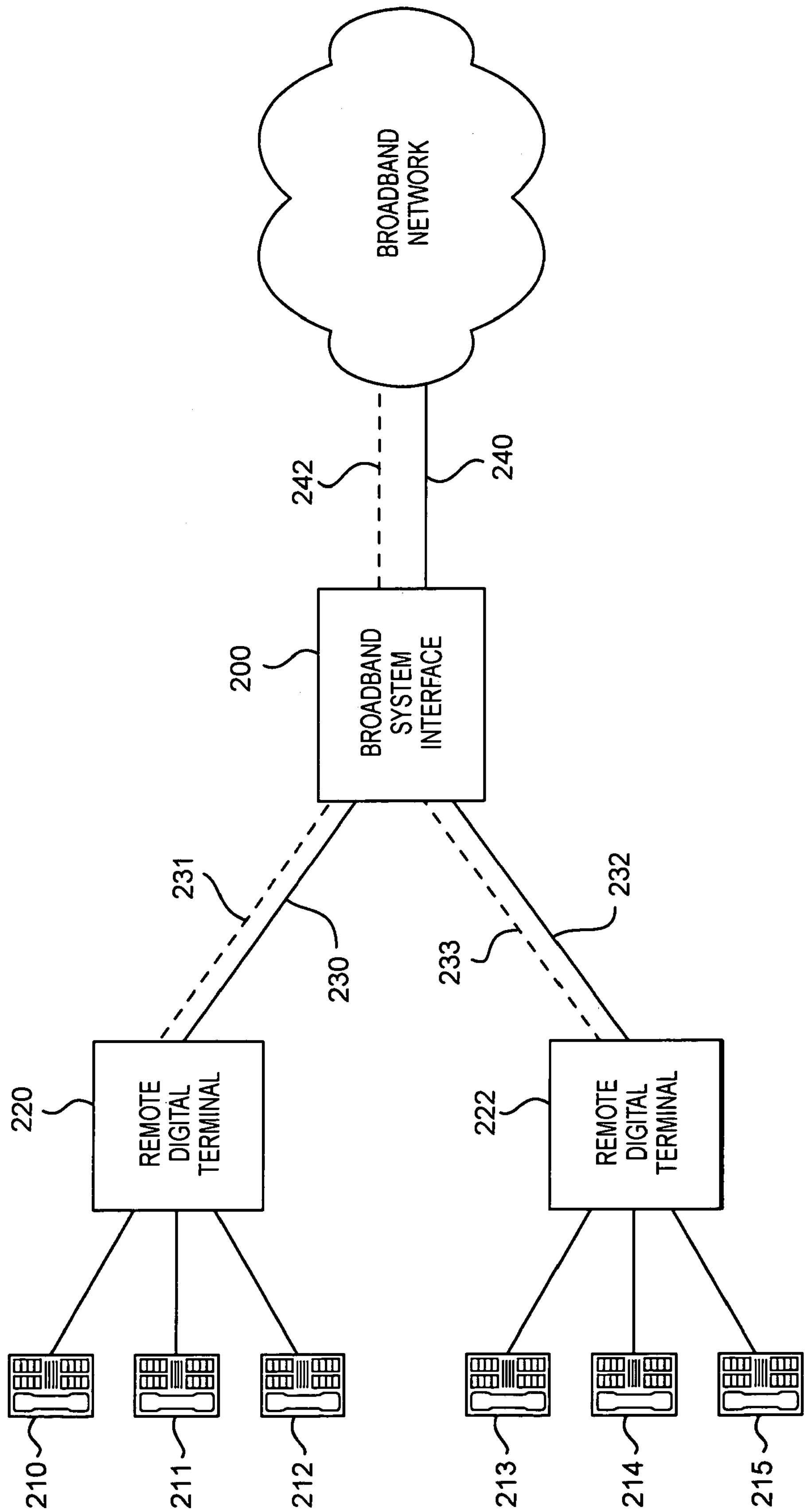

BROADBAND NETWORK
242
240
200
BROADBAND SYSTEM INTERFACE
231
230
232
233
220
REMOTE DIGITAL TERMINAL
222
REMOTE DIGITAL TERMINAL
210
211
212
213
214
215

FIG. 2

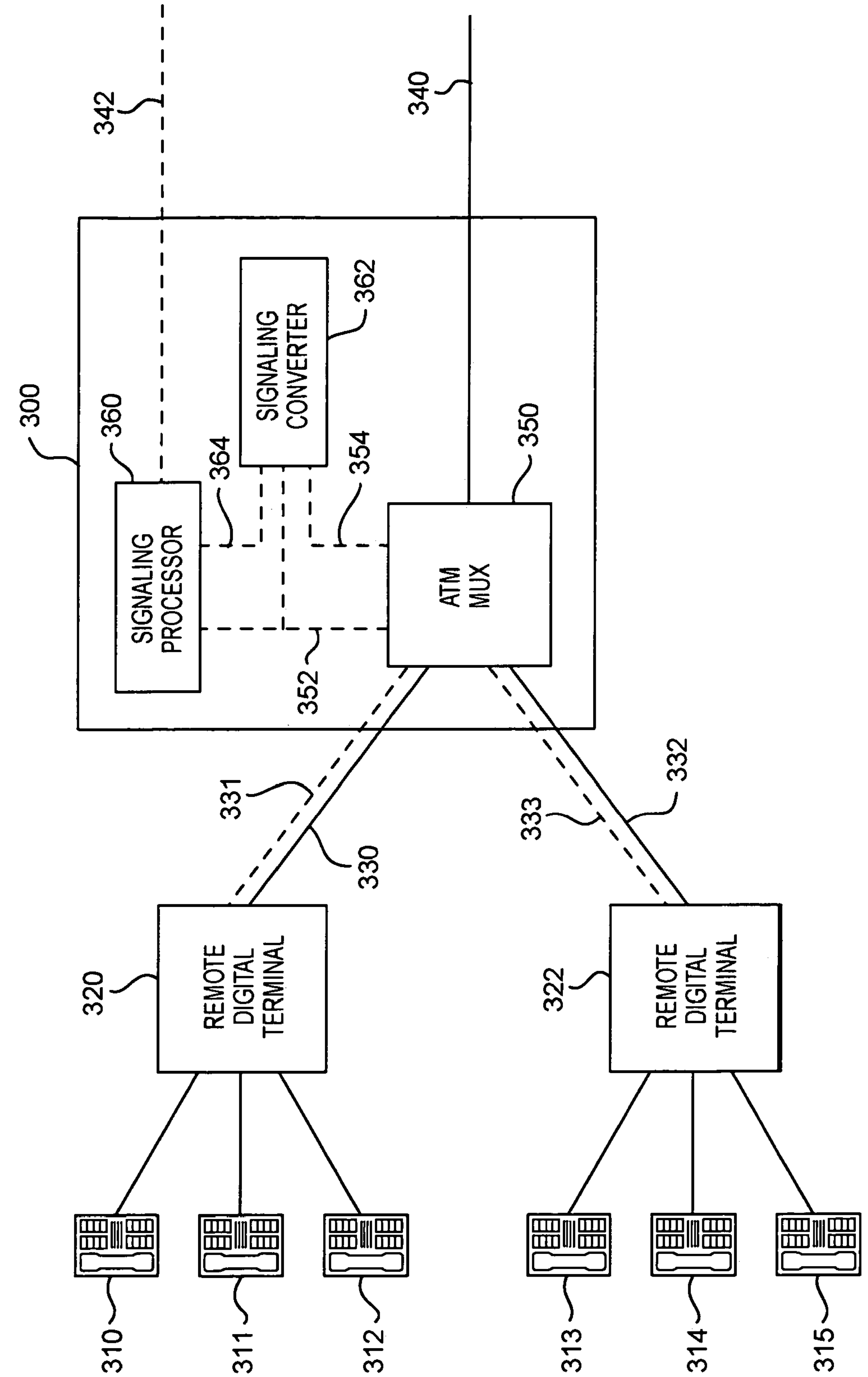

342
340
300
360
SIGNALING PROCESSOR
SIGNALING CONVERTER
362
364
354
350
ATM MUX
352
331
330
332
333
320
REMOTE DIGITAL TERMINAL
322
REMOTE DIGITAL TERMINAL
310
311
312
313
314
315

FIG. 3

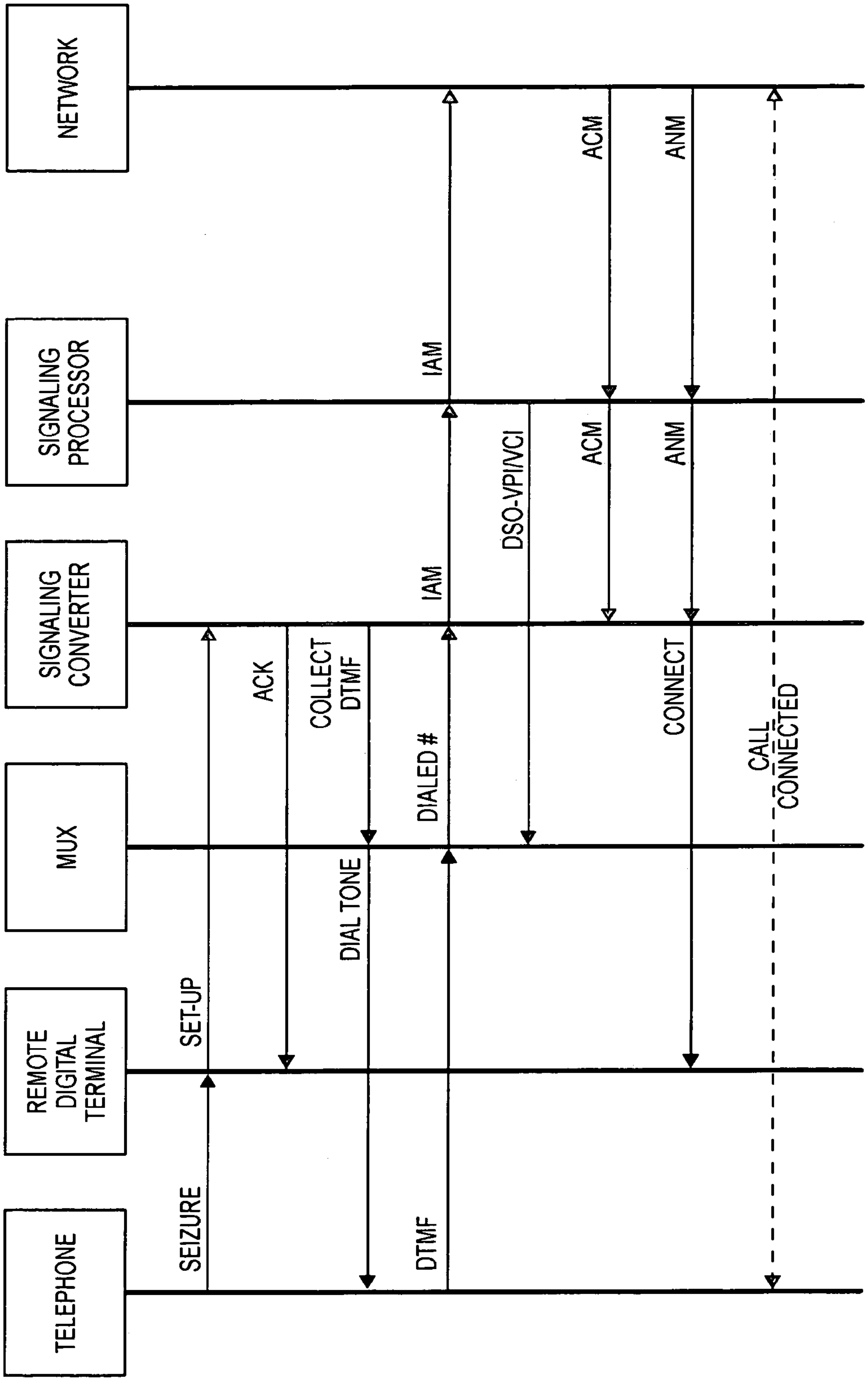

TELEPHONE
REMOTE DIGITAL TERMINAL
MUX
SIGNALING CONVERTER
SIGNALING PROCESSOR
NETWORK
SEIZURE
SET-UP
ACK
COLLECT DTMF
DIAL TONE
DTMF
DIALED #
IAM
IAM
DSO-VPI/VCI
ACM
ACM
ANM
ANM
CONNECT
CALL CONNECTED

FIG. 4

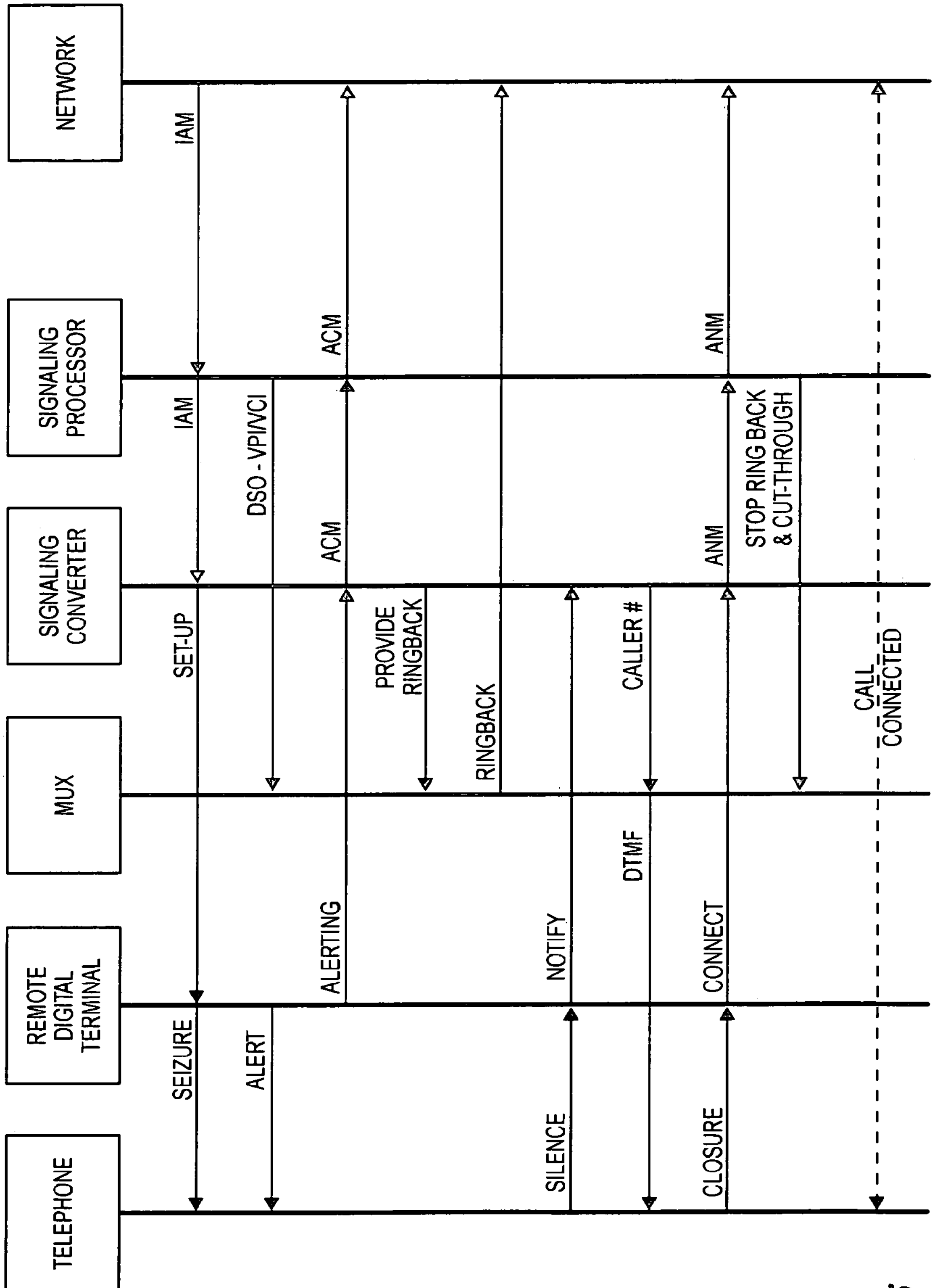

NETWORK
SIGNALING PROCESSOR
SIGNALING CONVERTER
MUX
REMOTE DIGITAL TERMINAL
TELEPHONE
IAM
IAM
SET-UP
SEIZURE
DSO - VPI/VCI
ALERT
ACM
ACM
ALERTING
PROVIDE RINGBACK
RINGBACK
NOTIFY
SILENCE
CALLER #
DTMF
ANM
ANM
STOP RING BACK & CUT-THROUGH
CONNECT
CLOSURE
CALL CONNECTED

FIG. 5

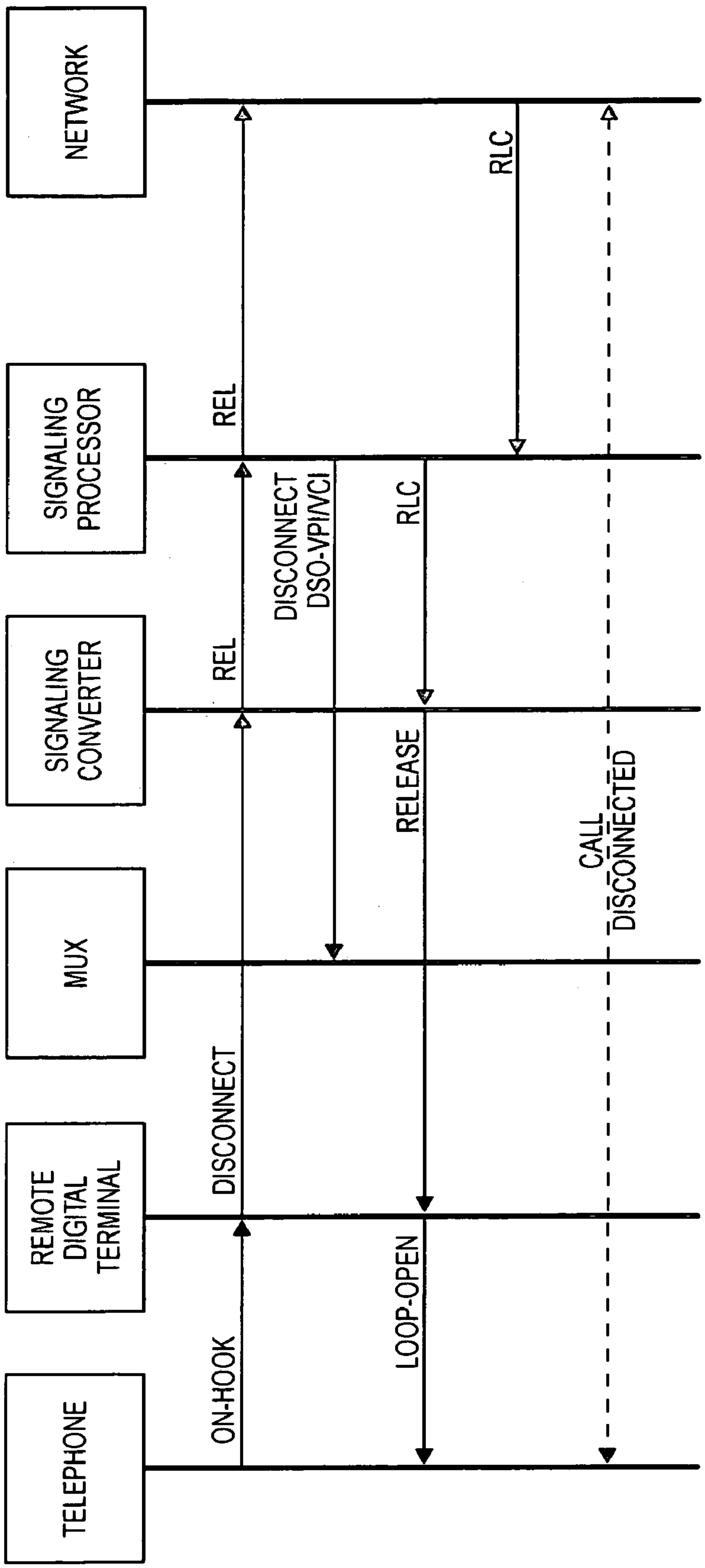
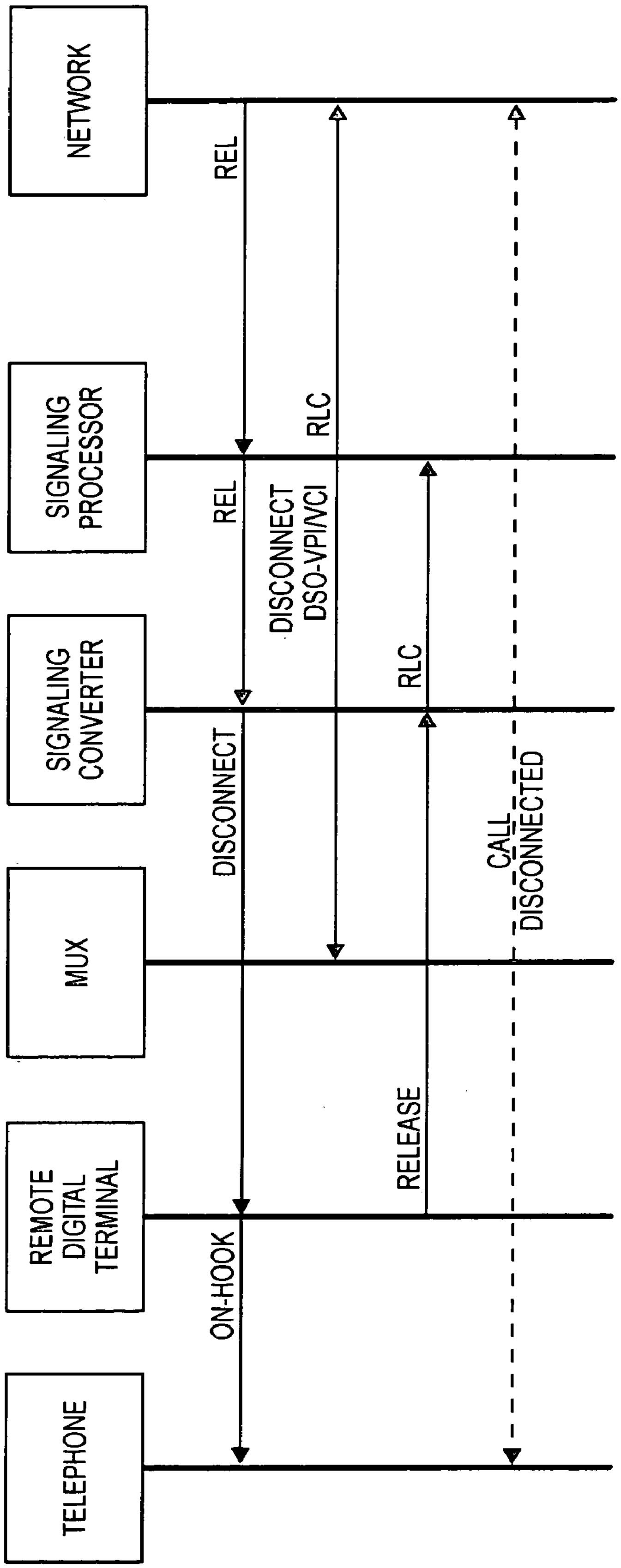
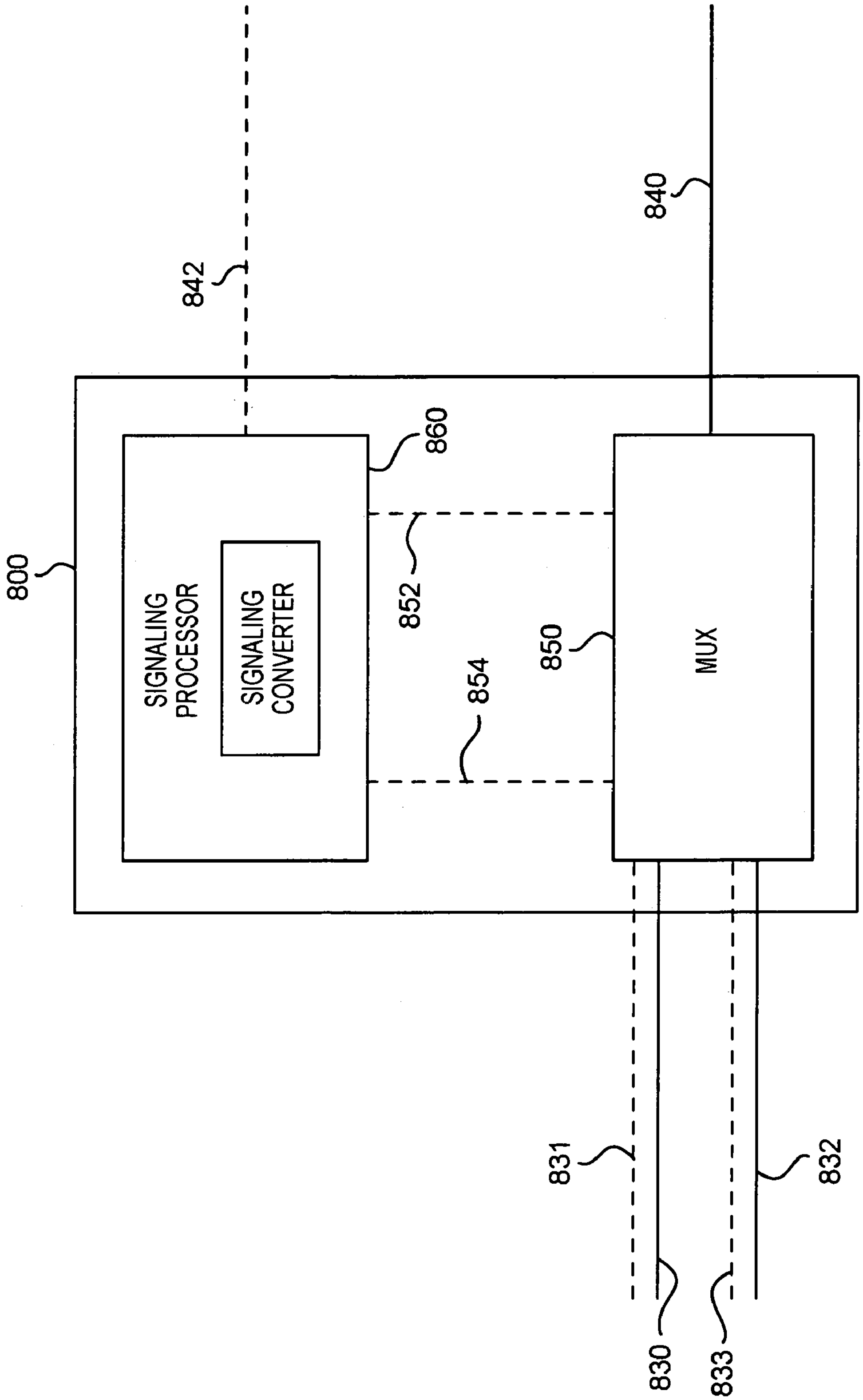

NETWORK
SIGNALING PROCESSOR
SIGNALING CONVERTER
MUX
REMOTE DIGITAL TERMINAL
TELEPHONE
ON-HOOK
DISCONNECT
REL
REL
DISCONNECT DSO-VPI/VCI
RLC
RLC
RELEASE
LOOP-OPEN
CALL DISCONNECTED

FIG. 6



NETWORK
SIGNALING PROCESSOR
SIGNALING CONVERTER
MUX
REMOTE DIGITAL TERMINAL
TELEPHONE
REL
RLC
REL
DISCONNECT DSO-VPI/VCI
RLC
DISCONNECT
CALL DISCONNECTED
RELEASE
ON-HOOK

FIG. 7



800
842
840
860
SIGNALING PROCESSOR
SIGNALING CONVERTER
852
854
850
MUX
831
832
830
833

FIG. 8

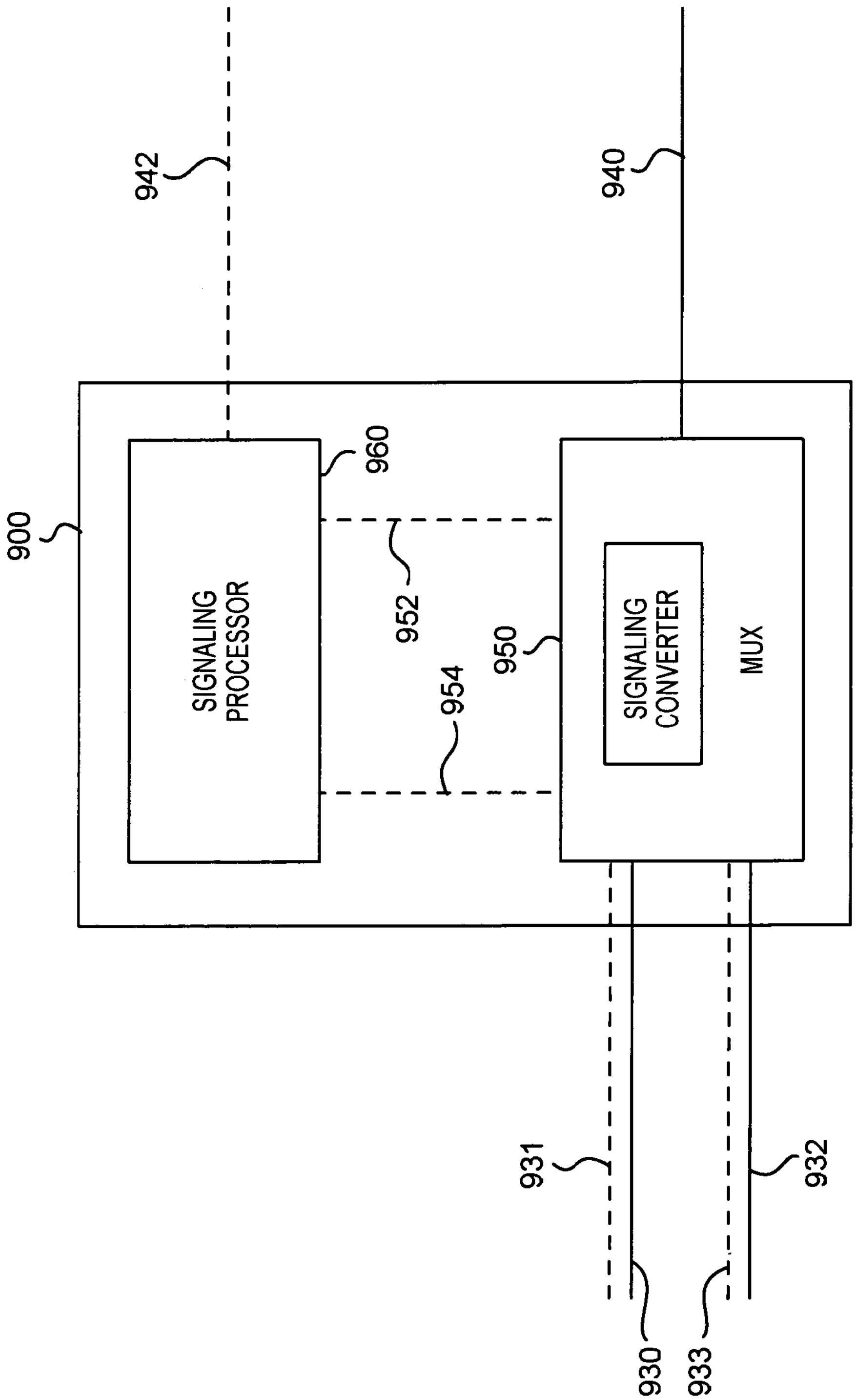

942
940
900
960
SIGNALING PROCESSOR
952
954
950
SIGNALING CONVERTER
MUX
931
932
930
933

FIG. 9

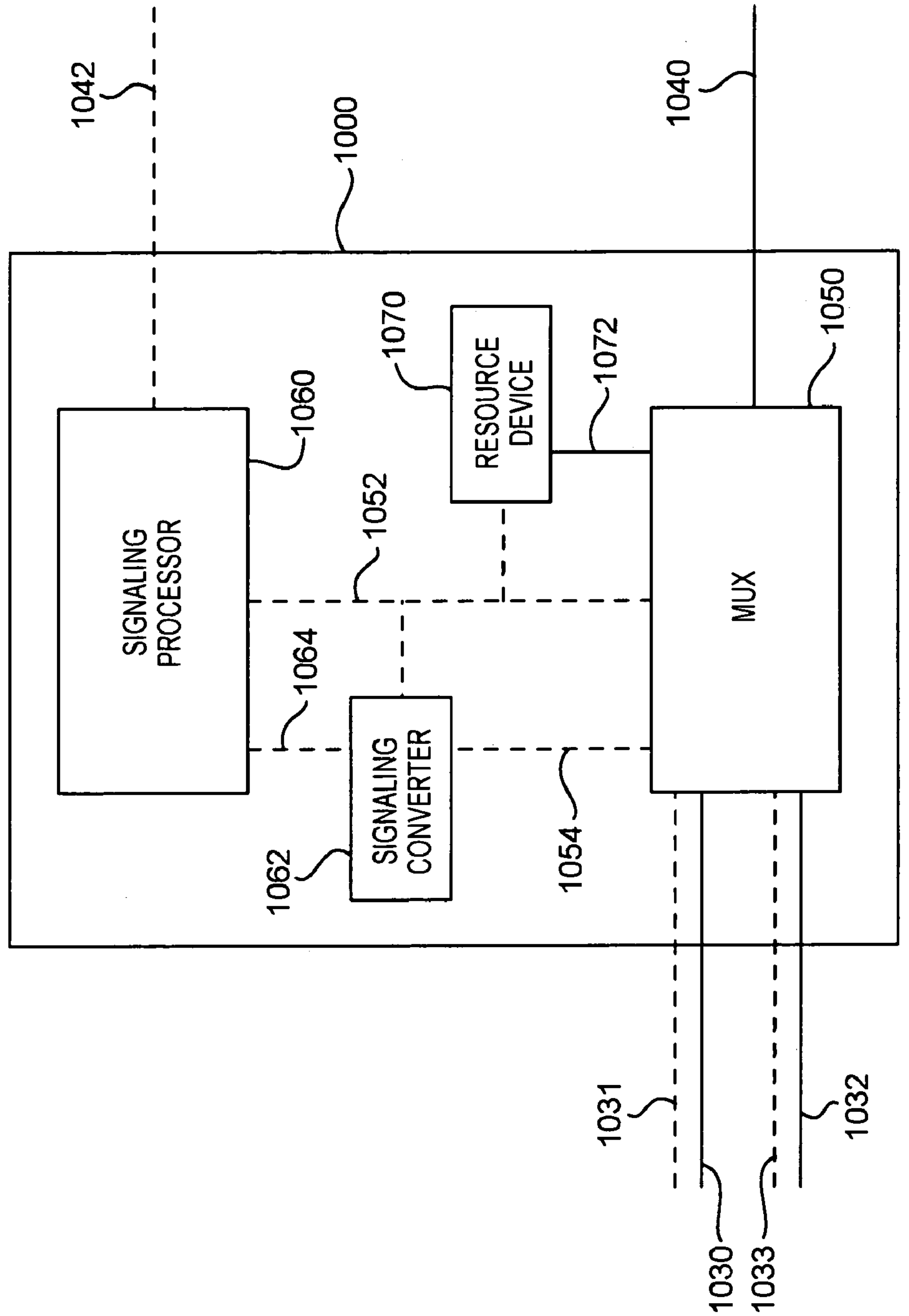

1042
1000
1040
1070
RESOURCE DEVICE
1072
1050
1060
SIGNALING PROCESSOR
1052
MUX
1064
SIGNALING CONVERTER
1054
1062
1031
1032
1030
1033

FIG. 10

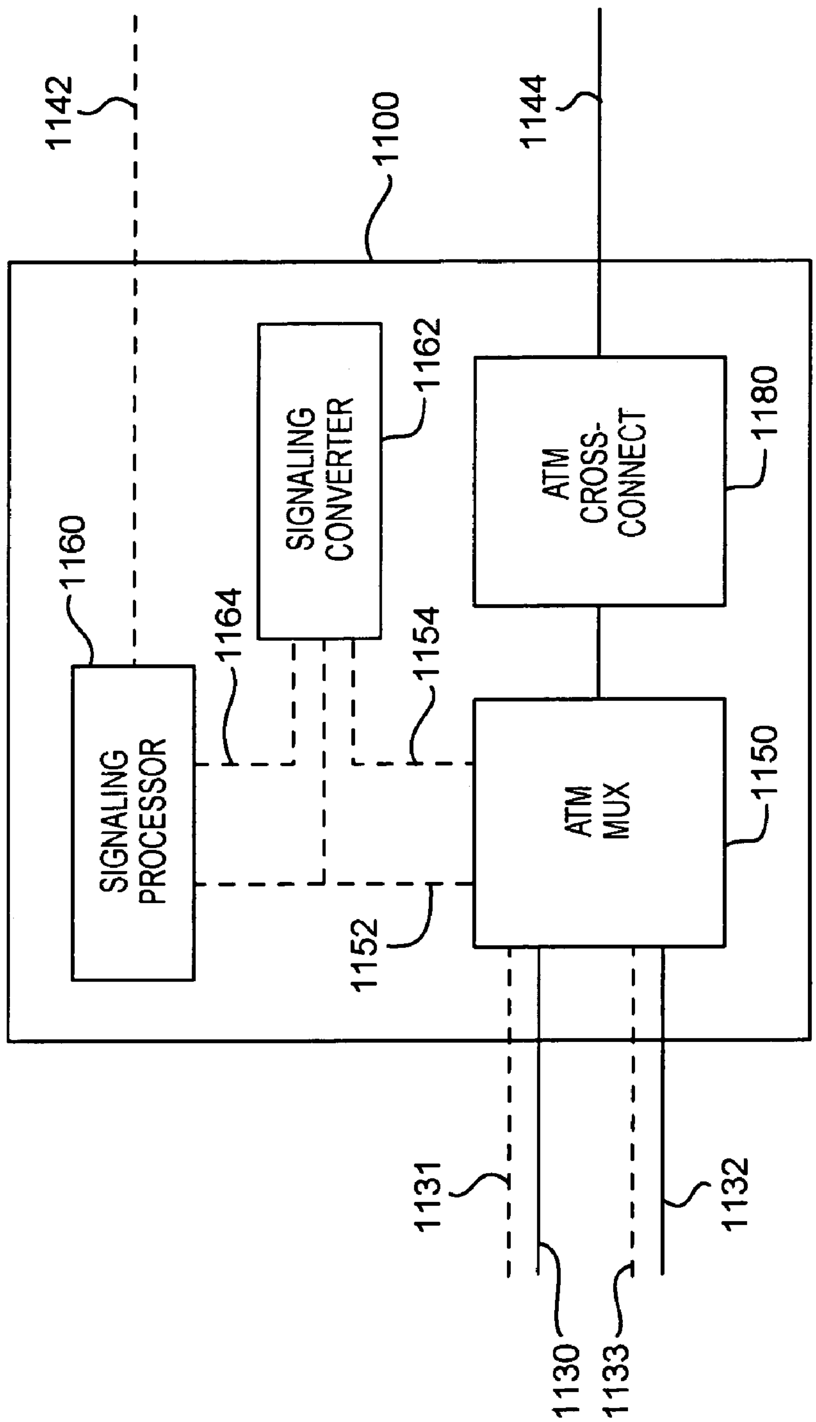

1142
1100
1144
SIGNALING CONVERTER
1162
ATM CROSS-CONNECT
1180
1160
1164
1154
SIGNALING PROCESSOR
ATM MUX
1150
1152
1131
1132
1130
1133

FIG. 11

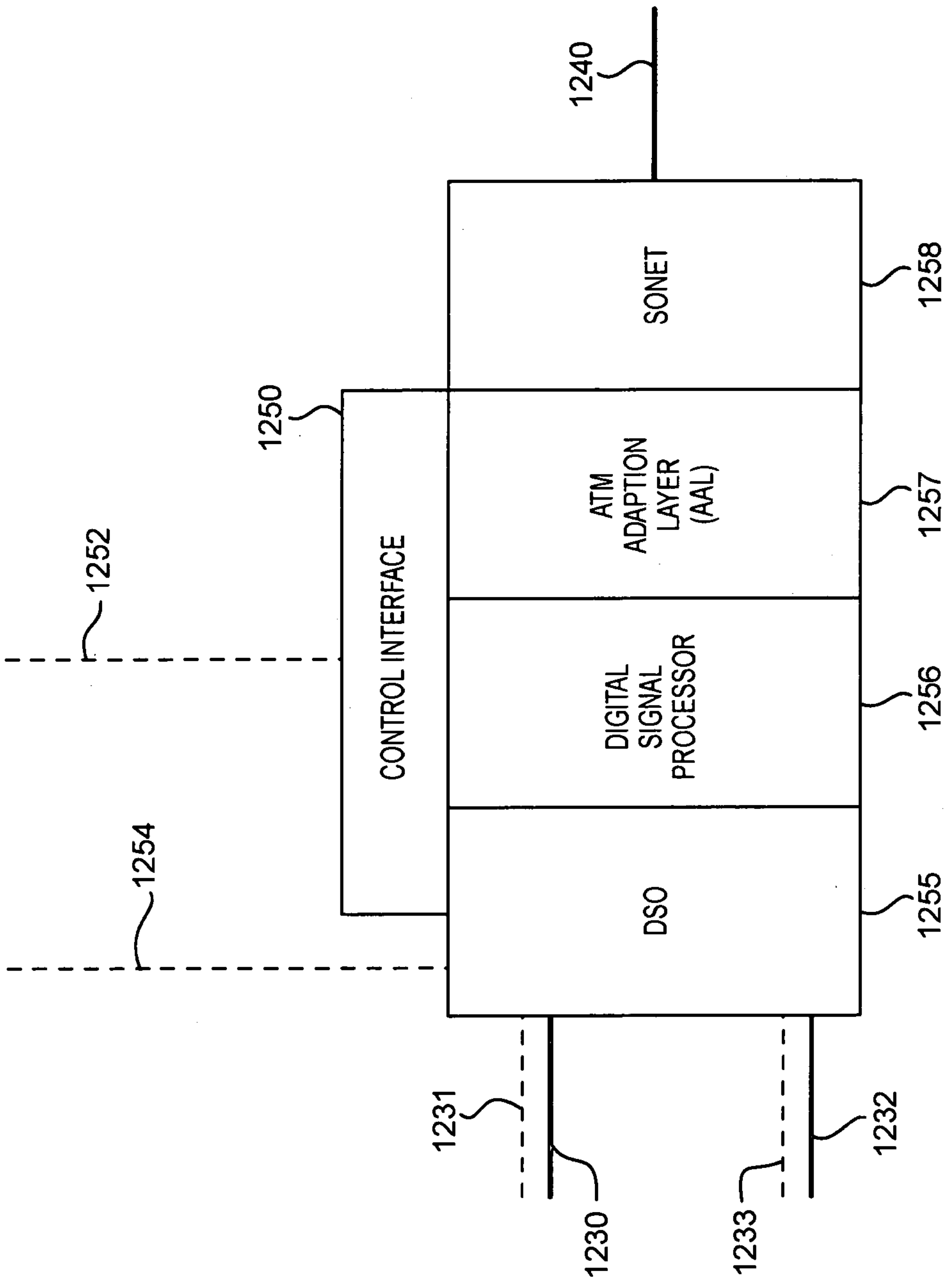

1240
SONET
1258
ATM ADAPTION LAYER (AAL)
1257
DIGITAL SIGNAL PROCESSOR
1256
DSO
1255
CONTROL INTERFACE
1250
1252
1254
1231
1230
1233
1232

FIG. 12

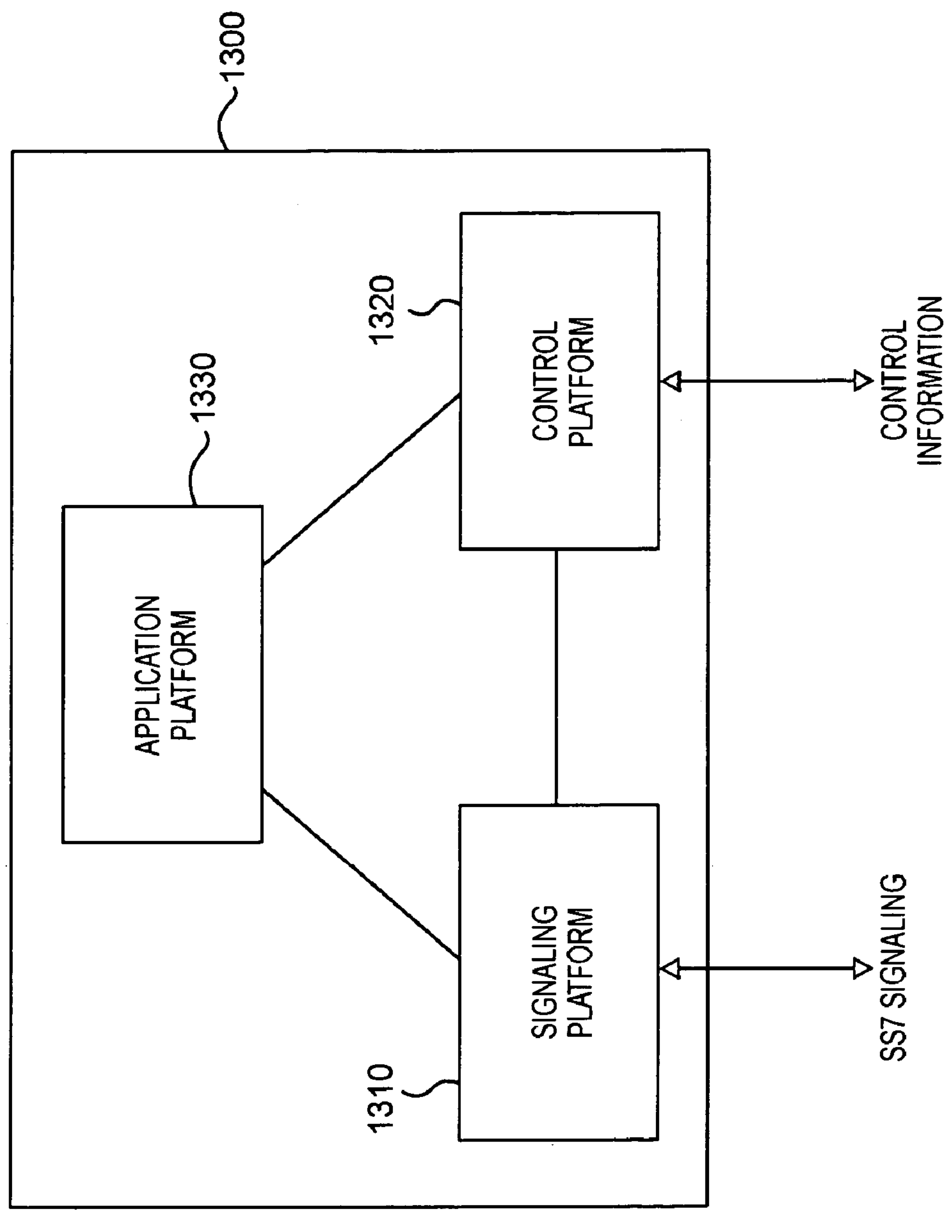

1300
1330
APPLICATION PLATFORM
1320
CONTROL PLATFORM
CONTROL INFORMATION
1310
SIGNALING PLATFORM
SS7 SIGNALING

FIG. 13

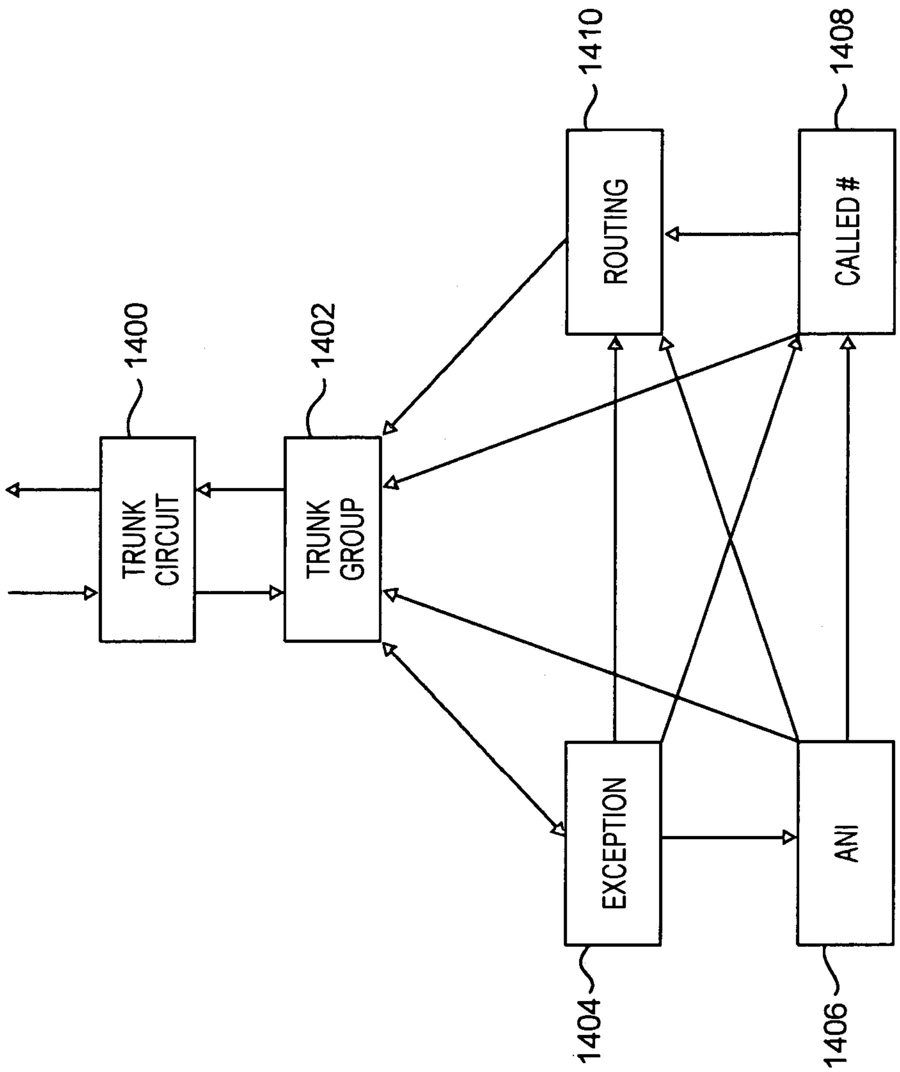

1400
TRUNK CIRCUIT
1402
TRUNK GROUP
1410
ROUTING
1408
CALLED #
EXCEPTION
1404
ANI
1406

FIG. 14

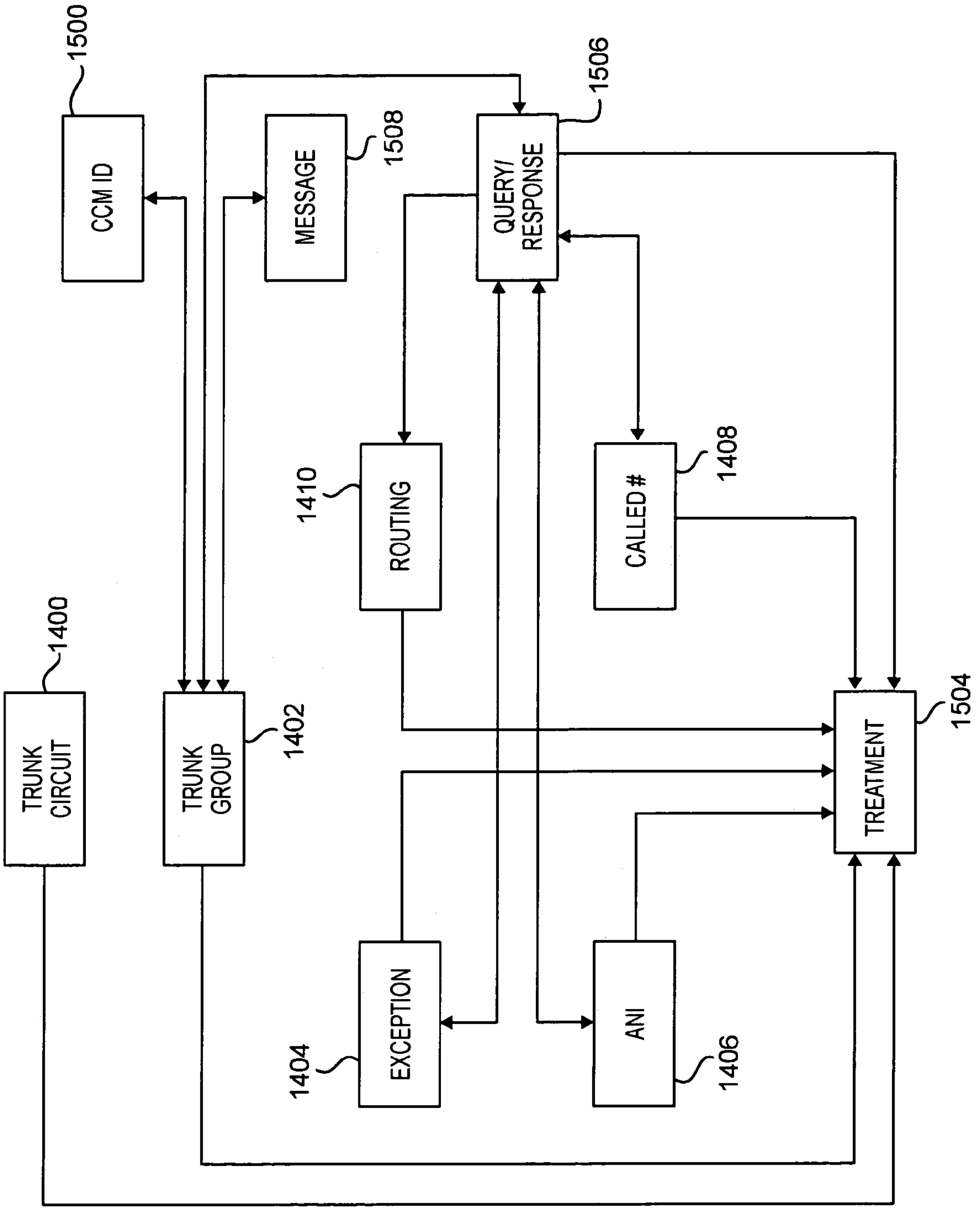

1500
CCM ID
MESSAGE
1508
QUERY/ RESPONSE
1506
1410
ROUTING
CALLED #
1408
1400
TRUNK CIRCUIT
TRUNK GROUP
1402
TREATMENT
1504
1404
EXCEPTION
ANI
1406

FIG. 15

ASSOCIATED POINT CODE	CIC	VP	VC	TRUNK GROUP NUMBER	GROUP MEMBER NUMBER	HARDWARE IDENTIFIER	ECHO CANCELER	ECHO CONTROL	SATELLITE INDICATOR	CIRCUIT STATUS	CIRCUIT STATE	TIME/ DATE

FIG. 16

TRUNK GROUP NUMBER	GLARE RESOLUTION	CONTINUITY CONTROL	CLLI	SATELLITE TRUNK GROUP	SERVICE INDICATOR	ASSOCIATED NPA	SELECTION SEQUENCE	HOP COUNTER	ACC ACTIVE	OMI	NEXT FUNCTION	INDEX

FIG. 17

EXCEPTION TABLE INDEX	CARRIER SELECTION IDENTIFICATION	CARRIER IDENTIFICATION	CALLED PARTY			NEXT FUNCTION	INDEX
			NATURE OF ADDRESS	DIGITS FROM	DIGITS TO		

FIG. 18

ANI TABLE INDEX	CALLING PARTY CATEGORY	NATURE OF ADDRESS	CALLING PARTY/CHARGE NUMBER			ORIGINATING LINE INFORMATION	NEXT FUNCTION	NEXT INDEX
			DIGITS FROM	DIGITS TO	DATA			

FIG. 19

CALLED NUMBER TABLE INDEX	NATURE OF ADDRESS	DIGITS FROM	DIGITS TO	NEXT FUNCTION	NEXT INDEX

FIG. 20

ROUTING TABLE INDEX	TRANSIT NETWORK SELECTION			CIRCUIT CODE	NEXT FUNCTION #1	INDEX #1	NEXT FUNCTION #2	INDEX #2	NEXT FUNCTION #3	INDEX #3
	NETWORK IDENTIFICATION PLAN	DIGITS FROM	DIGITS TO							

FIG. 21

INDEX	MESSAGE RECEIVED CAUSE VALUE	GENERAL LOCATION	CODING STANDARD	CAUSE VALUE	NEXT FUNCTION	INDEX

FIG. 22

MESSAGE TYPE	PARAMETERS	INDEX #1	INDEX #...	INDEX #N
ADDRESS COMPLETE	BACKWARD CALL INDICATOR			
	ACCESS TRANSPORT			
	CAUSE INDICATOR			
	OPTIONAL BACKWARD CALL INDICATORS			
	OPTIONAL "FE" INDICATOR			
ANSWER	ACCESS TRANSPORT			
	BACKWARD CALL INDICATOR			
CALL PROGRESS	EVENT INFORMATION			
	BACKWARD CALL INDICATOR			
	ACCESS TRANSPORT			
	CAUSE INDICATOR			
	OPTIONAL BACKWARD CALL INDICATOR			
CIRCUIT RESERVATION	NATURE OF CONNECTION INDICATOR			
CIRCUIT RESERVATION ACK	N/A			
CONFUSION	N/A			
CONTINUITY	CONTINUITY INDICATOR			
EXIT	OUTGOING TRUNK GROUP NUMBER			
INFORMATION	ALL PARAMETERS			
INFORMATION REQUEST	ALL PARAMETERS			
INITIAL ADDRESS	NATURE OF CONNECTION INDICATOR			
	FORWARD CALL INDICATOR			
	CALLING PARTY'S CATEGORY			
	USER SERVICE INFORMATION			
	CALLED PARTY NUMBER			
	ACCESS TRANSPORT			
	CALLING PARTY NUMBER			
	CARRIER IDENTIFICATION			
	CARRIER SELECTION INFORMATION			
	CHARGE NUMBER			
	GENERIC ADDRESS			
	ORIGINATING LINE INFORMATION			
	ORIGINAL CALLED NUMBER			
	REDIRECTING NUMBER			
	SERVICE CODE			
	TRANSIT NETWORK SELECTION			
	HOP COUNTER			
PASS ALONG	ALL PARAMETERS			
RELEASE	CAUSE INDICATOR			
	ACCESS TRANSPORT			
	AUTOMATIC CONGESTION CONTROL			
RELEASE COMPLETE	N/A			
RESUME	SUSPEND/RESUME INDICATOR			
SUSPEND	SUSPEND/RESUME INDICATOR			

FIG. 23

BROADBAND TELECOMMUNICATIONS SYSTEM INTERFACE

RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 10/237,759, which is a continuation of U.S. Pat. No. 6,470,009, which is a continuation of U.S. Pat. No. 6,304,580, which is a continuation of U.S. Pat. No. 6,023,474, and which are all incorporated by reference into this application.

FEDERALLY SPONSERED RESEARCH OR DEVELOPMENT

Not applicable

MICROFICHE APPENDIX

Not applicable

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to telecommunications, and in particular, to systems that provide access between GR-303 systems and broadband systems.

2. Background of the Prior Art

FIG. **1** depicts a common prior art arrangement for local telecommunications access. Shown are telephones that are connected to a local switch through remote digital terminals. Typically, there are several more telephones connected to each remote digital terminal, but the number depicted has been restricted for purposes of clarity. The connections between the telephones and the remote digital terminals typically carry analog signals over twisted pair wires. but other connections are also known. The remote digital terminals provide a digital interface between the callers and the local switch by converting the analog signals from the callers into a multiplexed digital signal for the local switch. A common standard for the connection between the remote digital terminal and the local switch is provided in Bellcore Reference GR-TSY-000303 (GR-303). The GR-303 format is very similar to the Integrated Services Digital Network (ISDN) format. ISDN has bearer channels (B) and a signaling channel (D) that are typically combined at the primary rate (23B+D) or at the basic rate (2B+D). Both the ISDN format and the GR-303 format are well known.

At present, broadband systems are being developed and implemented. Broadband systems provide telecommunications service providers with many benefits, including higher capacities, more efficient use of bandwidth, and the ability to integrate voice, data, and video communications. These broadband systems provide callers with increased capabilities at lower costs. However, callers may not have broadband terminals that can access these broadband systems. These callers need an effective interface that provides them with access to sophisticated broadband systems without the need for their own broadband terminals. Telecommunications service providers also need such an interface in order to use their broadband systems to provide services to a larger base of users.

SUMMARY OF THE INVENTION

The invention includes a telecommunications system that interworks between a broadband system, such as an Asynchronous Transfer Mode (ATM) system, and a GR-303 system for telecommunications calls. The telecommunications system-comprises a signaling processing system, a signaling interface, and a bearer interface. The signaling processing system is operational to process call signaling from the GR-303 system and from the ATM system, to select at least one of a GR-303 connection and an ATM connection for each call, and to provide control messages that identify the selected connections. The signaling interface that is operational to exchange the call signaling between the GR-303 system and the signaling processing system. The bearer interface that is operational to receive the control messages from the signaling processing system and to interwork call communications between the GR-303 system and the ATM system on the selected connections based on the control messages.

In some embodiments the signaling processing system is also operational to interwork the signaling from the GR-303 system and Signaling System #7 (SS7) signaling. Other embodiments include a remote digital terminal, an ATM cross-connect, an ATM multiplexer, a signaling converter, or a signaling processor.

The invention also includes a method for operating a telecommunications system that interworks between a GR-303 system and an Asynchronous Transfer Mode (ATM) system for telecommunications calls. The method comprises receiving GR-303 signaling and GR-303 communications into the telecommunications system. The GR-303 signaling is converted into Signaling System #7 (SS7) signaling, which is processed to select ATM connections. The GR-303 connections are interworked with the selected ATM connections.

In some embodiments, the method also includes receiving SS7 signaling and ATM communications into the telecommunications system. The SS7 signaling is processed to select GR-303 connections, and the ATM communications are interworked with the selected GR-303 connections. In some embodiments, the method also includes receiving additional GR-303 signaling and additional GR-303 communications into the telecommunications system. The additional GR-303 signaling is converted into additional Signaling System #7 (SS7) signaling which is processed to select GR-303 connections. The additional GR-303 communications are interconnected with the selected GR-303 connections.

The invention provides callers with an effective interface to sophisticated broadband systems without the need for their own broadband terminals. The invention provides telecommunications service providers with an interface that can use broadband systems to provide services to a large base of users.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of a version of the prior art.

FIG. **2** is a block diagram of a version of the present invention.

FIG. **3** is a block diagram of a version of the present invention.

FIG. **4** is a message sequence chart for a version of the present invention.

FIG. **5** is a message sequence chart for a version of the present invention.

FIG. **6** is a message sequence chart for a version of the invention.

FIG. **7** is a message sequence chart for a version of the invention.

FIG. **8** is a block diagram of a version of the invention.

FIG. **9** is a block diagram of a version of the invention.
FIG. **10** is a block diagram of a version of the invention.
FIG. **11** is a block diagram of a version of the invention.
FIG. **12** is a block diagram of a version of the invention.
FIG. **13** is a block diagram of a version of the present invention.
FIG. **14** is a logic diagram of a version of the present invention.
FIG. **15** is a logic diagram of a version of the present invention.
FIG. **16** depicts an example of the trunk circuit table.
FIG. **17** depicts an example of the trunk group table.
FIG. **18** depicts an example of the exception table.
FIG. **19** depicts an example of the ANI table.
FIG. **20** depicts an example of the called number table.
FIG. **21** depicts an-example of the routing table.
FIG. **22** depicts an example of the treatment table.
FIG. **23** depicts an example of the message table.

DETAILED DESCRIPTION

FIG. **1** depicts the prior art arrangement discussed above for providing access to a telecommunications system. In this arrangement, telephones are connected over analog connections to remote digital terminals. The remote digital terminals convert the analog signals into a multiplexed digital signal that is based on the GR-303 standard. The local switch accepts the GR-303 formatted signal and provides the callers with telephone service. All of these components and connections are well known in the art.

FIG. **2** depicts a version of the invention. Telephones **210-215** are shown connected to remote digital terminals **220** and **222**. These telephones and remote digital terminals are connected and function as discussed above with respect to FIG. **1**. It should be noted that although only telephones are shown, the invention is fully applicable to numerous other types of communications devices seeking access to a broadband system. Examples would include wireless devices, computers, modems, and facsimile machines. These devices may employ many forms of connections to remote digital terminals **220** and **222**, for example, wireless and co-axial connections. Also shown on FIG. **2** is broadband system interface **200**. Broadband system interface **200** replaces the local switch of FIG. **1**. Broadband system interface **200** is connected to remote digital terminal **220** by connection **230** and link **231**. Broadband system interface **200** is connected to remote digital terminal **222** by connection **232** and link **233**. Connections **230** and **232** are based on the GR-303 format and represent the bearer channels. Links **231** and **233** are based on the GR-303 format and represent the signaling channels. Also shown are connection **240** and signaling link **242**. Connection **240** is a broadband connection, for example a Synchronous Optical Network (SONET) connection carrying Asynchronous Transfer Mode (ATM) cells. Other forms of broadband connections are also applicable. Signaling link **242** carries telecommunications signaling; for example Signaling System #7 (SS7) messages. Other forms of signaling links are also applicable. Connection **240** and link **242** are connected to a broadband network cloud that represents any number of network elements such as switches, enhanced platforms, and servers to name some examples.

The operation of broadband system **200** includes the conversion of bearer communications and signaling from one format into another. Bearer communications are the user information, for example, voice traffic. Signaling is information used by the network, for example, a called number. In some embodiments the conversion process is described with the term "interworking". This term is well known to those in the art. For example, GR-303 signaling is interworked with SS7 signaling by converting GR-303 signaling into analogous SS7 signaling and by converting SS7 signaling into analogous GR-303 signaling. GR-303 bearer communications are interworked with ATM communications by converting GR-303 bearer communications into analogous ATM communications and by converting ATM communications into analogous GR-303 communications.

Broadband system interface **200** accepts calls in the GR-303 format from connection **230** and link **231** and from connection **232** and link **233**. Broadband system interface **200** provides a bearer interface for the GR-303 bearer channels and a signaling interface for the GR-303 signaling channels. The signaling interface provides the GR-303 signaling to a signaling processing system in broadband system interface **200**. The signaling processing system processes the call signaling and selects connections for the calls. The bearer interface receives communications from the GR-303 bearer channels and implements the selected connections in response to instructions from the signaling processing system. Typically, this requires interworking between GR-303 connections and broadband connections, and the connections can be selected on a call-by-call basis. Broadband system interface **200** may route calls to one of the other telephones connected to remote digital terminals **220** or **222**. In addition, broadband interface system **200** may route calls over broadband connection **240** and associated signaling over link **242**. Connection **240** and link **242** could connect callers to many other networks and network elements that provide numerous services.

It can be seen that broadband system interface **200** provides callers with access to a broadband system. In can also be seen that broadband system **200** is capable of accepting calls in the standard GR-303 format currently used by local switches.

FIG. **3** depicts a version of the invention, although one skilled in the art will recognize variations from this version that are also contemplated for the invention. Shown are telephones **310-315**, remote digital terminals **320** and **322**, and broadband system interface **300**. Broadband system interface **300** is comprised of ATM interworking multiplexer (mux) **350**, signaling processor **360**, and signaling converter **362**. Remote digital terminal **320** is connected to mux **350** by connection **330** and link **331**. Remote digital terminal **322** is connected to mux **350** by connection **332** and link **333**. Mux **350**, signaling processor **360**, and converter **362** are linked by link **352**. Mux **350** is linked to signaling converter **362** by link **354**. Signaling converter **362** is linked to signaling processor by link **364**. Mux **350** is also connected to connection **340** and signaling processor **360** is also linked to link **342**.

Telephones **310-315**, remote digital terminals **320** and **322**, connections **330** and **332**, and links **331** and **333** are as described above. Connections **320** and **322** and links **331** and **333** comprise GR-303 multiplexed digital signals. The GR-303 multiplexed digital signal is comprised of multiple bearer channels that carry caller communications and a signaling channel that carries caller signaling. Link **352** could be any link capable of transporting control messages. Examples of such a link could be SS7 links, UDP/IP or TCP/IP over ethernet, or a bus arrangement using a conventional bus protocol. Link **354** carries DS0s that comprise GR-303 signaling channels. Links **342** and **364** are SS7 links. Connection **340** is an ATM connection.

Mux **350** provides the bearer interface and the signaling interface. Mux **350** is operational to receive GR-303 formatted communications over connections **330** and **332** and links **331** and **333**. The bearer channels from connections **330** and **332** and the signaling channels from links **331** and **333** are in the well known DS0 format. Mux **350** is able to connect each DS0 to any other DS0. Mux **350** connects the DS0 from link **331** to a DS0 of link **354** to provide a GR-303 signaling channel from remote digital terminal **320** to signaling converter **362**. Mux **350** connects the DS0 from link **333** to a DS0 of link **354** to provide a GR-303 signaling channel from remote digital terminal **322** to signaling converter **362**. Mux **350** can also connect DS0s that carry user communications. For example, a DS0 from telephone **310** could be connected to a DS0 for telephone **314**. Mux **350** can make this latter DS0 to DS0 connection in response to control instructions from signaling processor **360** that are received over link **352**.

Mux **350** is also operational to convert DS0s into ATM cells with selected Virtual Path Identifiers/Virtual Channel Identifiers (VPI/VCIs). This conversion is known as ATM interworking. These ATM cells are transmitted over connection **340**. Typically, they are provided to an ATM cross-connect device that routes the cells according to their VPI/VCI. Since DS0s are bi-directional, a companion VPI/VCI will typically be pre-assigned to the selected VPI/VCI to provide a call connection back to the caller. The mux would convert ATM cells from this companion VPI/VCI into the return path of the DS0. Mux **350** makes the DS0/ATM conversions in response to control instructions from signaling processor **360** that are received over link **352**.

In this embodiment, mux **350** also includes digital signal processing capability that can detect and provide tones for particular DS0s. For example, Mux **350** could apply dial tone to a particular DS0 in response to a control instruction from signaling converter **362**. Mux **350** could then detect the DTMF inputs received from the caller over the DS0 and provide this information to signaling converter **362** over link **352**. A detailed description of the mux is given below.

Signaling processor **360** and signaling converter **362** comprise a signaling processing system that is operational to receive GR-303 signaling and select connections. It can also receive SS7 signaling and select connections. These two components can be integrated or remain discreet.

Signaling converter **362** interworks between GR-303 signaling and SS7 signaling. Signaling converter **362** exchanges GR-303 signaling with remote terminal devices **320** and **322** over links **354**, **331**, and **333** (and through mux **350**). Signaling converter **362** exchanges SS7 signaling with signaling processor **360** over link **364**. GR-303 relies on the LAPD and Q.931 protocols established for ISDN D channel signaling. Devices that convert ISDN D channel signaling onto the SS7 format are known. One skilled in the art will appreciate how such a device could be adapted to convert GR-303 signaling into the SS7 format.

In some embodiments, signaling converter **362** will generate and transmit control instructions to mux **350** over link **354** to collect DTMF input from a caller. This will typically occur in response to a GR-303 set-up message. After these digits are collected by mux **350**, signaling converter **362** will receive a message from mux **350** over link **352** that identifies the digits dialed by the caller. These digits will be incorporated into an SS7 message sent to signaling processor **360**. Signaling converter **362** may also instruct mux **350** to provide ringback to caller at the far end of the call. The mux would provide a ringback to the caller at the far end that indicates the called party at the near end was being alerted.

Where appropriate, a busy signal may be provided. Signaling converter **262** may also instruct the mux to provide the callers number to the called party. This could be used for the caller ID feature.

Signaling processor **360** is operational to process signaling. The signaling processor will typically process an SS7 Initial Address Message (IAM) for call set-up. The signaling information is processed by signaling processor **360** in order to select a particular connection for a particular call. This connection might be a DS0 or a VPI/VCI. Signaling processor **360** sends control instructions to mux **350** identifying the selected connections. A detailed description of the signaling processor follows below.

FIG. **4** depicts the operation of the invention in the form of a message sequence chart. FIG. **4** depicts a call being placed from a telephone (for example, telephone **310** in FIG. **3**) to an entity across the country. The sequence starts with the telephone seizing a connection to the remote digital terminal. This could be done by the telephone going off-hook. The remote digital terminal senses the off-hook condition and sends a GR-303 set-up message to the signaling converter through the mux. (As the mux transfers all messages between the signaling converter and the remote digital terminal, express reference to this transfer will be omitted in the following discussions). The set-up message identifies the DS0 used by the remote digital terminal for the call. The signaling converter provides a set-up acknowledgment back to the remote digital terminal and instructs the mux to collect DTMF from the DS0 for the call. The mux provides dial tone to the selected DS0 and internally connects the DS0 to digit collection apparatus. (On ground start circuits at this time, the remote digital terminal will send tip-ring voltage to the telephone and receive loop closure from the telephone—these are not shown). The telephone responds with the caller's DTMF input. The mux detects the DTMF input and provides a message to the signaling converter identifying the dialed number. The signaling converter converts the GR-303 set-up message into an analogous SS7 IAM containing the dialed number from the mux and sends the SS7 IAM to the signaling processor.

The signaling processor processes the SS7 IAM and selects a connection. For a cross-country call, this connection would typically be a VPI/VCI provisioned to a long distance network. The signaling processor will generate an SS7 IAM and send it on to the relevant network element to extend the call. The signaling processor also sends a control instruction to the mux identifying the DS0 and VPI/VCI.

Once the far end has received all information required for the call, it will return an SS7 Address Complete Message (ACM) to the signaling processor, which will pass another ACM to the signaling converter. At this time, the far end typically returns a ringback tone that indicates that the called party is being alerted (or a busy signal if appropriate). This ringback tone is passed to the telephone over the VPI/VCI—DS0 connection. If the called party answers, the signaling processor will receive an SS7 Answer Message (ANM) from the far end. The signaling processor will send an SS7 ANM message to the converter, and the converter will send an analogous GR-303 connect message to the remote digital terminal.

At this point, the call is connected and a conversation, fax transmission, etc., may take place. The mux converts caller information on the DS0 into ATM cells for the selected VPI/VCI. Additionally, the mux converts ATM cells received from the companion VPI/VCI into the return path of the DS0. As a result, the caller has access to an ATM system through the GR-303 interface. Advantageously, the

VPI/VCI is selected on a call-by-call basis by the signaling processor. This allows the signaling processor to select a virtual connection that has been pre-provisioned to an appropriate destination.

FIG. **5** depicts a call from an entity across the country to the same telephone of FIG. **4**. The sequence begins with an SS7 IAM from origination side of the call being received by the signaling processor. The signaling processor processes the IAM and selects the destination DS0. The signaling processor sends an IAM to the signaling converter which forwards an analogous GR-303 set-up message to the remote digital terminal. The set-up message identifies the selected DS0 to use on the call. The signaling processor also sends a control instruction to the mux identifying the VPI/VCI and the selected DS0 for the call.

The remote digital terminal provides seizure and an alerting signal to the telephone. The remote digital terminal will send a GR-303 alerting message to the signaling converter and the signaling converter will send an analogous SS7 Address Complete Message (ACM) to the signaling processor. The signaling converter will also instruct the mux to provide a ringback tone to the originating side of the call (or a busy signal where appropriate). The mux will provide a ringback to the caller indicating to the caller that the called party is being alerted. The signaling processor will send an SS7 ACM to the origination side of the call.

The remote digital terminal will sense a silent interval after the first ring and will send a GR-303 notify message to the signaling converter. Upon receipt, the signaling converter instruct the mux to pass the calling number to the telephone and the mux will pass the requisite DTMF tones to the telephone. When the remote digital terminal senses that the telephone has been answered, it will send a GR-303 connect message to the signaling converter, and the signaling converter will provide an analogous SS7 ANM to the signaling processor. The signaling processor will 'send an SS7 ANM to the originating side of the call. The signaling processor will instruct the mux to stop the ringback and provide cut-through for the call. At this point, the call is connected.

FIG. **6** depicts a call being cleared when the telephone of FIGS. **4** and **5** hangs-up. The remote digital terminal senses the on-hook and sends a GR-303 disconnect message to the signaling converter. The signaling converter sends an analogous SS7 release (REL) message to the signaling processor. The signaling processor sends an SS7 REL to the other side of the call connection and-also sends the mux an instruction to disconnect the DS0 from the VPI/VCI. The signaling processor will then send an SS7 Release Complete Message (RLC) to the signaling converter, and the converter will send an analogous GR-303 release message to the remote digital converter. The remote digital converter will provide a loop open to the telephone. The far side of the call will typically respond with a SS7 Release Complete Message (RLC) to the signaling processor as well. At this point, the call is disconnected.

FIG. **7** depicts a call being cleared when the far end of the call hangs-up. The far end will send an SS7 REL to the signaling processor, and the signaling processor will initiate release procedures for the call. The signaling processor will send an SS7 REL to the signaling converter, and the signaling converter will send an analogous GR-303 disconnect message to the remote digital terminal. The remote digital terminal provides an on-hook to the telephone. The signaling processor will also provide a control instruction to the mux to disconnect the DS0 from the VPI/VCI, and will send an SS7 RLC to the other side of the call. When the remote digital terminal senses an on-hook from the telephone signaling processor, it will provide a GR-303 release message to the converter. The converter will provide an analogous SS7 RLC to the signaling processor indicating that the connection has been cleared for re-use. At this point, the call is disconnected.

In FIGS. **4**-**7**, the caller is provided with an interface to a broadband system through a conventional GR-303 remote digital terminal. The network is able to provide this interface and provide selected ATM connection on a call-by-call basis—all without the need for an ATM switch or call-by-call control over an ATM cross-connect. Such a system provides a distinct advantage over prior systems.

The mux may implement DS0 to DS0 connections for particular calls. Referring to FIG. **3**, if a call is placed from telephone **310** to telephone **314**, a DS0 from telephone **310** and a DS0 to telephone **314** would be selected by signaling processor **360**. Mux **350** would cross-connect the two DS0s in response to a command from signaling processor **360**. Note that this occurs without converting the DS0s into ATM. In the alternative, the signaling processor may select a VPI/VCI for the call. The VPI/VCI would be pre-provisioned back to mux **350** for connection to, the DS0 for telephone **314**.

In some embodiments, particular telephones may be pulse dial instead of DTMF tone dial. The remote digital terminals are operational to detect the digits outpulsed by the telephones and to provide GR-303 information messages to the signaling converter (through the mux). The remote digital terminal can also receive an information message and outpulse the calling number to a called telephone. In these scenarios, the mux will not need to exchange DTMF with the telephones. The signaling converter exchanges GR-303 information messages with the remote digital interfaces. The signaling processor will exchange this information with the signaling converter through SS7 messages, and will not need to instruct the mux to exchange DTMF with the caller.

In an alternative embodiment, the remote digital interface could be adapted to exchange DTMF digits and provide dial tone to the telephones. In this embodiment, the mux would not need to handle DTMF or dial tone. GR-303 set-up and information messages could be used to convey dialed numbers between the remote digital interface and the converter.

In some embodiments, the remote digital interface may use hybrid GR-303 signaling. Hybrid GR-303 signaling employs robbed-bit ABCD signaling for on-hook/off-hook status in addition to a channel for additional signaling. In these embodiments, the mux would be adapted to forward the signaling from the signaling channel and the ABCD robbed signaling bits to the converter. The converter would be adapted to convert both into analogous SS7 messages.

FIGS. **8**-**12** depict various alternative arrangements of the invention, but the invention is not limited to these alternatives. Those skilled in the art will appreciate how these variations could be combined in many other different arrangements that are all contemplated by the invention.

FIG. **8** depicts broadband system interface **800** that is comprised of mux **850**, signaling processor **860** and links **852** and **854**. Also shown are connections **830**, **832**, and **840**; and links **831**, **833**, and **842**. These components are configured and operate as described above for the corresponding reference numbers of FIG. **3**, except that the signaling converter has been incorporated into signaling processor **860**.

FIG. **9** depicts broadband system interface **900** that is comprised of mux **950**, signaling processor **960** and links **952** and **954**. Also shown are connections **930**, **932**, and **940**;

and links **931**, **933**, and **942**. These components are configured and operate as described above for the corresponding reference numbers of FIG. **3**, except that the signaling converter has been incorporated into mux **950**.

FIG. **10** depicts broadband system interface **1000** that is comprised of mux **1050**, signaling processor **1060**, signaling converter **1062**, and links **1052**, **1054**, and **1062**. Also shown are connections **1030**, **1032**, and **1040**; and links **1031**, **1033**, and **1042**. These components are configured and operate as described above except that resource device **1070** and connection **1072** have been added. Resource device **1070** is capable of providing various resources in response to control instructions. Examples of resources are: tone detection, tone transmission, loopbacks, voice detection, voice messaging, echo cancellation, compression, or and encryption. Resource device **1070** includes a processor to interpret the tones and communicate with other devices. Resource device **1070** communicates with signaling converter **1062** over link **1052**. One skilled in the art will recognize other features for resource device **1070**, such as interdigit timing and various other timing functions. In this way, multiplexer **1050** does not require all digital signal processing apparatus, but connects DS0s to resource device **1070** using connection **1072**. Connection **1072** is typically a T1 connection although other connections would suffice. Resource device **1070** is capable of exchanging control instructions over link **1052**.

FIG. **11** depicts broadband system interface **1100** that is comprised of mux **1150**, signaling processor **1160**, signaling converter **1162**, and links **1152**, **1154**, and **1164**. Also shown are connections **1130**, **1132**, and **1144**; and links **1131**, **1133**, and **1142**. These components are configured and operate as described above for the corresponding reference numbers of FIG. **3**, except that ATM cross-connect **1180** and connection **1182** have been added. ATM cross-connect **1180** is a conventional ATM cross-connect, such as an NEC model **20**. ATM cross-connect **1180** provides a plurality of pre-provisioned VPI/VCI connections for mux **1150** over connection **1182**. Connection **1182** is an ATM connection. These VPI/VCIs could be pre-provisioned through ATM cross-connect **1180** to a plurality of devices. Example include switches, servers, enhanced platforms, customer premises equipment, and other muxes. The VPI/VCIs could terminate in other networks. The addition of cross-connect **1180** demonstrates how the selection of VPI/VCIs by the signaling processor on a call-by-call basis allows broadband system interface **1100** to route calls to selected destinations over selected broadband connections.

This is accomplished without the need for an ATM switch. This provides a distinct advantage over current ATM switch based systems in terms of cost and control. ATM switches are typically very expensive and control over the switch is relegated to the switch supplier. In the invention, the signaling processor exerts the control, and the signaling processor does not need to be obtained from an ATM switch supplier.

The ATM Interworking Multiplexer

FIG. **12** shows one embodiment of the mux that is suitable for the present invention, but other muxes that support the requirements of the invention are also applicable. Shown are control interface **1250**, DS0 interface **1255**, digital signal processor **1256**, ATM adaption layer (AAL) **1257**, and SONET interface **1258**. SONET interface **1258** accepts ATM cells from AAL **1257** and transmits them over connection **1240**. Connection **1240** is a SONET connection, such as an OC-3 connection. Control interface **1250** exchanges control messages between the signaling processor, the signaling converter, and the elements of the mux.

DS0 interface **1255** accepts GR-303 formatted signals over connections **1230** and **1232**; and links **1231** and **1233**. DS0 interface **1255** is operational to cross-connect particular DS0s to other particular DS0s in response to control instructions. DS0 interface **1255** cross-connects the signaling channel DS0s of links **1231** and **1233** to the signaling channel DS0s of link **1254** to the signaling converter. The bearer channel DS0s are coupled to digital signal processor **1256** or AAL **1257** in response to control instructions. In some embodiments, DS0 interface **1255** can also monitor ABCD bits from hybrid GR-303 connections and provide this information to control interface **1250** for transfer to the signaling converter. DS0 interface **1255** provides reciprocal processing in the reverse direction as well. For example, GR-303 signaling messages from the signaling converter received over link **1254** are sent to the remote digital interface along with DS0 from either AAL **1257** or digital signal processor **1256**.

DS0 interface **1255** receives the DS0s and handles them in accord with signaling processor instructions received through control interface **1250**. This would include interconnecting particular DS0s to other DS0s on particular calls. It would also include connecting particular DS0s to particular functions of digital signal processor **1256** or AAL **1257**.

Digital signal processor **1256** is operational to apply various digital processes to particular DS0s in response to control instructions received through control interface **1250**. Examples of digital processing include: tone detection, tone transmission, loopbacks, voice detection, voice messaging, echo cancellation, compression, and encryption. For example, the signaling processor may instruct the mux to collect a DTMF dialed number, and then to apply echo cancellation to the DS0 prior to conversion to ATM.

Digital signal processor **1256** is connected to AAL **1257**. As discussed, DS0s from DS0 interface **1255** may bypass digital signal processor **1256** and be directly coupled to AAL **1257**. AAL **1257** comprises both a convergence sublayer and a segmentation and reassembly (SAR) layer. AAL **1257** is operational to accept the DS0 format and convert the DS0 information into ATM cells. AALs are known in the art and information about AALs is provided by International Telecommunications Union (ITU) document I.363. An AAL for voice is also described in U.S. Pat. No. 5,606,553, which is hereby incorporated by reference into this application. AAL **1257** obtains the virtual path identifier (VPI) and virtual channel identifier (VCI) for each call from control interface **1250**. AAL **1257** also obtains the identity of the DS0 for each call (or the DS0s for an Nx64 call). Control interface **1250** receives these instructions from the signaling processor. AAL **1257** then converts user information between the identified DS0 and the identified ATM virtual connection. Acknowledgments that the assignments have been implemented may be sent back to the signaling processor if desired. Calls with a bit rate that are a multiple of 64 kbit/second are known as Nx64 calls. If desired, AAL **1257** can be capable of accepting control messages through control interface **1250** for Nx64 calls. The signaling processor would instruct AAL **1257** to group the DS0s for the call.

As discussed above, the mux also handles calls in the opposite direction—from SONET interface **1258** to DS0 interface **1255**. For this communications, the VPI/VCI has typically been selected and the communications routed through the cross-connect. As a result, AAL **1257** needs only to identify the DS0 for that particular VPI/VCI. The signaling processor could provide this assignment through control

interface **1250** to AAL **1257**. A technique for processing VPI/VCIs is disclosed in U.S. Pat. No. 5,940,393, which is hereby incorporated by reference into this application.

DS0 connections are bi-directional and ATM connections are typically uni-directional. As a result, two virtual connections in opposing directions will typically be required for each DS0. Those skilled in the art will appreciate how this can be accomplished in the context of the invention. For example, the broadband system could be provisioned with a second set of VPI/VCIs in the opposite direction as the original set of VPI/VCIs. On each call, the mux would be configured to automatically invoke this second VPI/VCI to provide a bi-directional virtual connection to match the bi-directional DS0 on the call.

The Signaling Processor

The signaling processor is referred to as a call/connection manager (CCM), and it receives and processes telecommunications call signaling and control messages to select connections that establish communication paths for calls. In the preferred embodiment, the CCM processes SS7 signaling to select connections for a call. CCM processing is described in U.S. Pat. No. 6,031,840, which is incorporated herein by reference.

In addition to selecting connections, the CCM performs many other functions in the context of call processing. It not only can control routing and select the actual connections, but it can also validate callers, control echo cancelers, generate billing information, invoke intelligent network functions, access remote databases, manage traffic, and balance network loads. One skilled in the art will appreciate how the CCM described below can be adapted to operate in the above embodiments.

FIG. **13** depicts a version of the CCM. Other versions are also contemplated. In the embodiment of FIG. **13**, CCM **1300** controls an ATM interworking multiplexer (mux) that performs interworking of DS0s and VPI/VCIs. However, the CCM may control other communications devices and connections in other embodiments.

CCM **1300** comprises signaling platform **1310**, control platform **1320**, and application platform **1330**. Each of the platforms **1310**, **1320**, and **1330** is coupled to the other platforms.

Signaling platform **1310** is externally coupled to the SS7 systems—in particular to systems having a message transfer part (MTP), an ISDN user part (ISUP), a signaling connection control part (SCCP), an intelligent network application part (INAP), and a transaction capabilities application part (TCAP). Control platform **1320** is externally coupled to a mux control, an echo control, a resource control, billing, and operations.

Signaling platform **1310** comprises MTP levels 1-3, ISUP, TCAP, SCCP, and INAP functionality and is operational to transmit and receive the SS7 messages. The ISUP, SCCP, INAP, and TCAP functionality use MTP to transmit and receive the SS7 messages. Together, this functionality is referred as an "SS7 stack," and it is well known. The software required by one skilled in the art to configure an SS7 stack is commercially available, for example, from the Trillium company.

Control platform **1320** is comprised of various external interfaces including a mux interface, an echo interface, a resource control interface, a billing interface, and an operations interface. The mux interface exchanges messages with at least one mux. These messages comprise DS0 to VPI/VCI assignments, acknowledgments, and status information. The echo control interface exchanges messages with echo control systems. Messages exchanged with echo control systems might include instructions to enable or disable echo cancellation on particular DS0s, acknowledgments, and status information.

The resource control interface exchanges messages with external resources. Examples of such resources are devices that implement continuity testing, encryption, compression, tone detection/transmission, voice detection, and voice messaging. The messages exchanged with resources are instructions to apply the resource to particular DS0s, acknowledgments, and status information. For example, a message may instruct a continuity testing resource to provide a loopback or to send and detect a tone for a continuity test.

The billing interface transfers pertinent billing information to a billing system. Typical billing information includes the parties to the call, time points for the call, and any special features applied to the call. The operations interface allows for the configuration and control of CCM **1300**. One skilled in the art will appreciate how to produce the software for the interfaces in control platform **1320**.

Application platform **1330** is functional to process signaling information from signaling platform **1310** in order to select connections. The identity of the selected connections are provided to control platform **1320** for the mux interface. Application platform **1330** is responsible for validation, translation, routing, call control, exceptions, screening, and error handling. In addition to providing the control requirements for the mux, application platform **1330** also provides requirements for echo control and resource control to the appropriate interface of control platform **1320**. In addition, application platform **1330** generates signaling information for transmission by signaling platform **1310**. The signaling information might be ISUP, INAP, or TCAP messages to external network elements. Pertinent information for each call is stored in a call control block (CCB) for the call. The CCB can be used for tracking and billing the call.

Application platform **1330** operates in general accord with the Basic Call Model (BCM) defined by the ITU. An instance of the BCM is created to handle each call. The BCM includes an originating process and a terminating process. Application platform **1330** includes a service switching function (SSF) that is used to invoke the service control function (SCF). Typically, the SCF is contained in a service control point (SCP). The SCF is queried with TCAP or INAP messages. The originating or terminating processes will access remote databases with intelligent network (IN) functionality via the SSF function.

Software requirements for application platform **1330** can be produced in specification and description language (SDL) defined in ITU-T Z.100. The SDL can be converted into C code. Additional C and C++ code can be added as required to establish the environment.

CCM **1300** can be comprised of the above-described software loaded onto a computer. The computer can be an Integrated Micro Products (IMP) FT-Sparc 600 using the Solaris operating system and conventional database systems. It may be desirable to utilize the multi-threading capability of a Unix operating system.

From FIG. **13**, it can be seen that application platform **1330** processes signaling information to control numerous systems and facilitate call connections and services. The SS7 signaling is exchanged with external components through signaling platform **1310**, and control information is exchanged with external systems through control platform **1320**. Advantageously, CCM **1300** is not integrated into a switch CPU that is coupled to a switching matrix. Unlike an

SCP, CCM **1300** is capable of processing ISUP messages independently of TCAP queries.

SS7 Message Designations

SS7 messages are well known. Designations for various SS7 messages commonly are used. Those skilled in the art are familiar with the following message designations:

ACM—Address Complete Message
ANM—Answer Message
BLO—Blocking
BLA—Blocking Acknowledgment
CPG—Call Progress
CRG—Charge Information
CGB—Circuit Group Blocking
CGBA—Circuit Group Blocking Acknowledgment
GRS—Circuit Group Reset
GRA—Circuit Group Reset Acknowledgment
CGU—Circuit Group Unblocking
CGUA—Circuit Group Unblocking Acknowledgment
CQM—Circuit Group Query
CQR—Circuit Group Query Response
CRM—Circuit Reservation Message
CRA—Circuit Reservation Acknowledgment
CVT—Circuit Validation Test
CVR—Circuit Validation Response
CFN—Confusion
COT—Continuity
CCR—Continuity Check Request
EXM—Exit Message
INF—Information
INR—Information Request
IAM—Initial Address
LPA—Loop Back Acknowledgment
PAM—Pass Along
REL—Release
RLC—Release Complete
RSC—Reset Circuit
RES—Resume
SUS—Suspend
UBL—Unblocking
UBA—Unblocking Acknowledgment
UCIC—Unequipped Circuit Identification Code.

CCM Tables

Call processing typically entails two aspects. First, an incoming or "originating" connection is recognized by an originating call process. For example, the initial connection that a call uses to enter a network is the originating connection in that network. Second, an outgoing or "terminating" connection is selected by a terminating call process. For example, the terminating connection is coupled to the originating connection in order to extend the call through the network. These two aspects of call processing are referred to as the originating side of the call the terminating side of the call.

FIG. **14** depicts a data structure used by application platform **1330** to execute the BCM. This is accomplished through a series of tables that point to one another in various ways. The pointers are typically comprised of next function and next index designations. The next function points to the next table, and the next index points to an entry or a range of entries in that table. The data structure has trunk circuit table **1400**, trunk group table **1402**, exception table **1404**, ANI table **1406**, called number table **1408**, and routing table **1410**.

Trunk circuit table **1400** contains information related to the connections. Typically, the connections are DS0 or ATM connections. Initially, trunk circuit table **1400** is used to retrieve information about the originating connection. Later, the table is used to retrieve information about the terminating connection. When the originating connection is being processed, the trunk group number in trunk circuit table **1400** points to the applicable trunk group for the originating connection in trunk group table **1402**.

Trunk group table **1402** contains information related to the originating and terminating trunk groups. When the originating connection is being processed, trunk group table **1402** provides information relevant to the trunk group for the originating connection and typically points to exception table **1404**.

Exception table **1404** is used to identify various exception conditions related to the call that may influence the routing or other handling of the call. Typically, exception table **1404** points to ANI table **1406**. Although, exception table **1404** may point directly to trunk group table **1402**, called number table **1408**, or routing table **1410**.

ANI table **1406** is used to identify any special characteristics related to the caller's number. The caller's number is commonly known as automatic number identification (ANI). ANI table **1406** typically points to called number table **1408**. Although, ANI table **1406** may point directly to trunk group table **1402** or routing table **1410**.

Called number table **1408** is used to identify routing requirements based on the called number. This will be the case for standard telephone calls. Called number table **1408** typically points to routing table **1410**. Although, it may point to trunk group table **1402**.

Routing table **1410** has information relating to the routing of the call for the various connections. Routing table **1410** is entered from a pointer in either exception table **1404**, ANI table **1406**, or called number table **1408**. Routing table **1410** typically points to a trunk group in trunk group table **1402**.

When exception table **1404**, ANI table **1406**, called number table **1408**, or routing table **1410** point to trunk group table **1402**, they effectively select the terminating trunk group. When the terminating connection is being processed, the trunk group number in trunk group table **1402** points to the trunk group that contains the applicable terminating connection in trunk circuit table **1402**.

The terminating trunk circuit is used to extend the call. The trunk circuit is typically a VPI/VCI or a DS0. Thus it can be seen that by migrating through the tables, a terminating connection can be selected for a call.

FIG. **15** is an overlay of FIG. **14**. The tables from FIG. **14** are present, but for clarity, their pointers have been omitted. FIG. **15** illustrates additional tables that can be accessed from the tables of FIG. **14**. These include CCM ID table **1500**, treatment table **1504**, query/response table **1506**, and message table **1508**.

CCM ID table **1500** contains various CCM SS7 point codes. It can be accessed from trunk group table **1402**, and it points back to trunk group table **1402**.

Treatment table **1504** identifies various special actions to be taken in the course of call processing. This will typically result in the transmission of a release message (REL) and a cause value. Treatment table **1504** can be accessed from trunk circuit table **1400**, trunk group table **1402**, exception table **1404**, ANI table **1406**, called number table **1408**, routing table **1410**, and query/response table **1506**.

Query/response table **1506** has information used to invoke the SCF. It can be accessed by trunk group table **1402**, exception table **1404**, ANI table **1406**, called number table **1408**, and routing table **1410**. It points to trunk group table **1402**, exception table **1404**, ANI table **1406**, called number table **1408**, routing table **1410**, and treatment table **1504**.

Message table **1508** is used to provide instructions for messages from the termination side of the call. It can be accessed by trunk group table **1402** and points to trunk group table **1402**.

FIGS. **16-23** depict examples of the various tables described above. FIG. **16** depicts an example of the trunk circuit table. Initially, the trunk circuit table is used to access information about the originating circuit. Later in the processing, it is used to provide information about the terminating circuit. For originating circuit processing, the associated point code is used to enter the table. This is the point code of the switch or CCM associated with the originating circuit. For terminating circuit processing, the trunk group number is used to enter the table.

The table also contains the circuit identification code (CIC). The CIC identifies the circuit which is typically a DS0 or a VPI/VCI. Thus, the invention is capable of mapping the SS7 CICs to the ATM VPI/VCI. If the circuit is ATM, the virtual path (VP) and the virtual channel (VC) also can be used for identification. The group member number is a numeric code that is used for terminating circuit selection. The hardware identifier identifies the location of the hardware associated with the originating circuit. The echo canceler (EC) identification (ID) entry identifies the echo canceler for the originating circuit.

The remaining fields are dynamic in that they are filled during call processing. The echo control entry is filled based on three fields in signaling messages: the echo suppresser indicator in the IAM or CRM, the echo control device indicator in the ACM or CPM, and the information transfer capability in the IAM. This information is used to determine if echo control is required on the call. The satellite indicator is filled with the satellite indicator in the IAM or CRM. It may be used to reject a call if too many satellites are used. The circuit status indicates if the given circuit is idle, blocked, or not blocked. The circuit state indicates the current state of the circuit, for example, active or transient. The time/date indicates when the idle circuit went idle.

FIG. **17** depicts an example of the trunk group table. During origination processing, the trunk group number from the trunk circuit table is used to key into the trunk table. Glare resolution indicates how a glare situation is to be resolved. Glare is dual seizure of the same circuit. If the glare resolution entry is set to "even/odd," the network element with the higher point code controls the even circuits, and the network element with the lower point code controls the odd circuits. If the glare resolution entry is set to "all," the CCM controls all of the circuits. If the glare resolution entry is set to "none," the CCM yields. The continuity control entry lists the percent of calls requiring continuity tests on the trunk group.

The common language location identifier (CLLI) entry is a Bellcore standardized entry. The satellite trunk group entry indicates that the trunk group uses a satellite. The satellite trunk group entry is used in conjunction with the satellite indicator field described above to determine if the call has used too many satellite connections and, therefore, must be rejected. The service indicator indicates if the incoming message is from a CCM (ATM) or a switch (TDM). The outgoing message index (OMI) points to the message table so that outgoing messages can obtain parameters. The associated number plan area (NPA) entry identifies the area code.

Selection sequence indicates the methodology that will be used to select a connection. The selection sequence field designations tell the trunk group to select circuits based on the following: least idle, most idle, ascending, descending, clockwise, and counterclockwise. The hop counter is decremented from the IAM. If the hop counter is zero, the call is released. Automatic congestion control (ACC) active indicates whether or not congestion control is active. If automatic congestion control is active, the CCM may release the call. During termination processing, the next function and index are used to enter the trunk circuit table.

FIG. **18** depicts an example of the exception table. The index is used as a pointer to enter the table. The carrier selection identification (ID) parameter indicates how the caller reached the network and is used for routing certain types of calls. The following are used for this field: spare or no indication, selected carrier identification code presubscribed and input by the calling party, selected carrier identification code presubscribed and not input by the calling party, selected carrier identification code presubscribed and no indication of input by the calling party, and selected carrier identification code not presubscribed and input by the calling party. The carrier identification (ID) indicates the network that the caller wants to use. This is used to route calls directly to the desired network. The called party number nature of address differentiates between 0+ calls, 1+ calls, test calls, and international calls. For example, international calls might be routed to a pre-selected international carrier.

The called party "digits from" and "digits to" focus further processing unique to a defined range of called numbers. The "digits from" field is a decimal number ranging from 1-15 digits. It can be any length and, if filled with less than 15 digits, is filled with 0s for the remaining digits. The "digits to" field is a decimal number ranging from 1-15 digits. It can be any length and, if filled with less than 15 digits, is filled with 9s for the remaining digits. The next function and next index entries point to the next table which is typically the ANI table.

FIG. **19** depicts an example of the ANI table. The index is used to enter the table. The calling party category differentiates among types of calling parties, for example, test calls, emergency calls, and ordinary calls. The calling party\charge number entry nature of address indicates how the ANI is to be obtained. The following is the table fill that is used in this field: unknown, unique subscriber numbers, ANI not available or not provided, unique national number, ANI of the called party included, ANI of the called party not included, ANI of the called party includes national number, non-unique subscriber number, non-unique national number, non-unique international number, test line test code, and all other parameter values.

The "digits from" and "digits to" focus further processing unique to ANI within a given range. The data entry indicates if the ANI represents a data device that does not need echo control. Originating line information (OLI) differentiates among, ordinary subscriber, multiparty line, ANI failure, station level rating, special operator handling, automatic identified outward dialing, coin or non-coin call using database access, 800/888 service call, coin, prison/inmate service, intercept (blank, trouble, and regular), operator handled call, outward wide area telecommunications service, telecommunications relay service (TRS), cellular services, private paystation, and access for private virtual network types of service. The next function and next index point to the next table which is typically the called number table.

FIG. **20** depicts an example of the called number table. The index is used to make enter the table. The called number nature of address entry indicates the type of dialed number, for example, national versus international. The "digits from" and "digits to" entries focus further processing unique to a

range of called numbers. The processing follows the processing logic of the "digits from" and "digits to" fields in FIG. **18**. The next function and next index point to the next table which is typically the routing table.

FIG. **21** depicts an example of the routing table. The index is used to enter the table. The transit network selection (TNS) network identification (ID) plan indicates the number of digits to use for the CIC. The transit network selection "digits from" and "digits to" fields define the range of numbers to identify an international carrier. The circuit code indicates the need for an operator on the call. The next function and next index entries in the routing table are used to identify a trunk group. The second and third next function/index entries define alternate routes. The third next function entry can also point back to another set of next functions in the routing table in order to expand the number of alternate route choices. The only other entries allowed are pointers to the treatment table. If the routing table points to the trunk group table, then the trunk group table typically points to a trunk circuit in the trunk circuit table. The yield from the trunk circuit table is the terminating connection for the call.

It can be seen from FIGS. **16-21** that the tables can be configured and relate to one another in such a way that call processes can enter the trunk circuit table for the originating connection and can traverse through the tables by keying on information and using pointers. The yield of the tables is typically a terminating connection identified by the trunk circuit table. In some cases, treatment is specified by the treatment table instead of a connection. If, at any point during the processing, a trunk group can be selected, processing may proceed directly to the trunk group table for terminating circuit selection. For example, it may be desirable to route calls from a particular ANI over a particular set of trunk groups. In this case, the ANI table would point directly to the trunk group table, and the trunk group table would point to the trunk circuit table for a terminating circuit. The default path through the tables is: trunk circuit, trunk group, exception, ANI, called number, routing, trunk group, and trunk circuit.

FIG. **22** depicts an example of the treatment table. Either the index or the message received cause number are filled and are used to enter the table. If the index is filled and used to enter the table, the general location, coding standard, and cause value indicator are used to generate an SS7 REL. The message received cause value entry is the cause value in a received SS7 message. If the message received cause value is filled and used to enter the table, then the cause value from that message is used in a REL from the CCM. The next function and next index point to the next table.

FIG. **23** depicts an example of the message table. This table allows the CCM to alter information in outgoing messages. Message type is used to enter the table, and it represents the outgoing standard SS7 message type. The parameter is the pertinent parameter within the outgoing SS7 message. The indexes point to various entries in the trunk group table and determine if parameters can be unchanged, omitted, or modified in the outgoing messages.

Those skilled in the art will appreciate that variations from the specific embodiments disclosed above are contemplated by the invention. The invention should not be restricted to the above embodiments, but should be measured by the following claims.

We claim:

1. A method of operating a communication system, the method comprising:

transferring a dial tone from a bearer interface for a caller;

receiving Dual Tone Multi-Frequency (DTMF) signals from the caller into the bearer interface;

processing the DTMF signals in the bearer interface to determine a called number;

transferring a first message indicating the called number from the bearer interface to a processing system;

processing the called number in the processing system to select an identifier;

transferring a second message indicating the identifier from the processing system to the bearer interface; and

receiving the user communications into the bearer interface, and in response to the second message, converting the user communications into a packet format including the identifier and transferring the user communications in the packet format including the identifier to a communication network, wherein the communication network routes the user communications based on the identifier.

2. The method of claim **1** further comprising providing echo cancellation in the bearer interface.

3. The method of claim **1** further comprising providing compression for the user communications in the bearer interface.

4. The method of claim **1** further comprising providing voice detection in the bearer interface.

5. The method of claim **1** further comprising providing voice messaging in the bearer interface.

6. The method of claim **1** further comprising providing ringback in the bearer interface.

7. The method of claim **1** wherein the receiving the user communications comprises receiving the user communications in a GR-303 format.

8. The method of claim **1** wherein the processing system not in a telecommunication switch.

9. The method of claim **1** wherein the identifier comprises an asynchronous transfer mode virtual identifier.

10. The method of claim **1** wherein processing the called number to select the identifier comprises sending a signaling message to a network element.

11. A communication system comprising:

a bearer interface configured to transfer a dial tone for a caller, receive Dual Tone Multi-Frequency (DTMF) signals from the caller, process the DTMF signals to determine a called number, and transfer a first message indicating the called number;

a processing system configured to process the called number to select an identifier and transfer a second message indicating the identifier; and

wherein the bearer interface is further configured to receive the second message and the user communications, and in response to the second message, convert the user communications into a packet format including the identifier and transfer the user communications in the packet format including the identifier to a communication network, wherein the communication network routes the user communications based on the identifier.

12. The communication system of claim **11** wherein the bearer interface is configured to provide echo cancellation.

13. The communication system of claim **11** wherein the bearer interface is configured to provide compression for the user communications.

14. The communication system of claim **11** wherein the bearer interface is configured to provide voice detection.

15. The communication system of claim **11** wherein the bearer interface is configured to provide voice messaging.

16. The communication system of claim **11** wherein the bearer interface is configured to provide ringback.

17. The communication system of claim **11** wherein the bearer interface is configured to receive the user communications in a GR-303 format.

18. The communication system of claim **11** wherein the processing system not in a telecommunication switch.

19. The communication system of claim **11** wherein the identifier comprises an asynchronous transfer mode virtual identifier.

20. The communication system of claim **11** wherein the processing system is configured to send a signaling message to a network element when processing the called number to select the identifier.

* * * * *

EXHIBIT M

US007693131B2

(12) **United States Patent**
Kaplan et al.

(10) **Patent No.: US 7,693,131 B2**
(45) **Date of Patent: Apr. 6, 2010**

(54) **TELECOMMUNICATIONS SYSTEM TO PROVIDE ANALOG TELEPHONY COMMUNICATIONS OVER A PACKET CONNECTION**

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(73) Assignee: **Sprint Communications Company L.P.**, Overland Park, KS (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1220 days.

(21) Appl. No.: **10/894,852**

(22) Filed: **Jul. 20, 2004**

(65) **Prior Publication Data**

US 2004/0264444 A1 Dec. 30, 2004

Related U.S. Application Data

(63) Continuation of application No. 09/650,560, filed on Aug. 30, 2000, now Pat. No. 6,829,234, which is a continuation of application No. 08/826,641, filed on Apr. 4, 1997, now Pat. No. 6,141,339.

(51) **Int. Cl.**
H04L 12/66 (2006.01)
H04J 3/16 (2006.01)
H04J 3/22 (2006.01)

(52) **U.S. Cl.** **370/352**; 370/466

(58) **Field of Classification Search** .... None
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,410,343	A		4/1995	Coddington et al.
5,610,910	A		3/1997	Focsaneanu et al.
5,629,926	A		5/1997	Deutsch et al.
5,737,333	A		4/1998	Civanlar et al.
5,805,591	A		9/1998	Naboulsi et al.
5,917,815	A		6/1999	Byers et al.
5,956,334	A	*	9/1999	Chu et al. 370/395.2
5,991,292	A	*	11/1999	Focsaneanu et al. 370/352
5,991,301	A		11/1999	Christie
6,075,784	A		6/2000	Frankel et al.
6,141,339	A		10/2000	Kaplan et al.
6,407,997	B1		6/2002	DeNap et al.

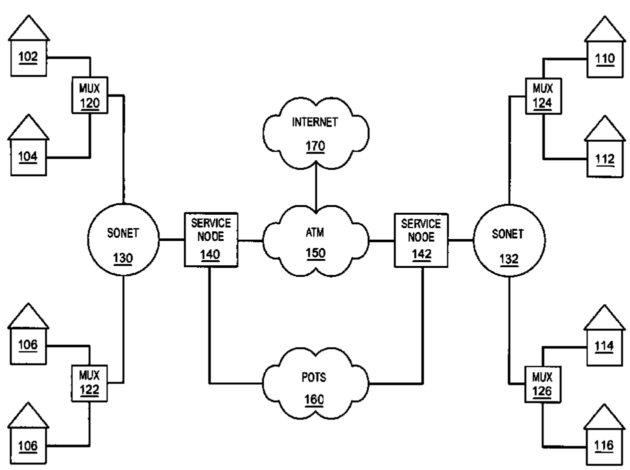
(Continued)

Primary Examiner—Ayaz R Sheikh
Assistant Examiner—Blanche Wong

(57) **ABSTRACT**

A communication system provides PSTN access to a user device coupled to a packet network over a packet connection. The user device exchanges telephony signaling and telephony communications in an analog format with an analog telephone, exchanges the telephony signaling and the telephony communications in the packet format over the packet connection, and exchanges Internet communications over the packet connection. A service node exchanges the telephony signaling in the packet format with the user device, processes the telephony signaling to select a PSTN connection, transfers a control message indicating the PSTN connection, and exchanges the telephony signaling in a PSTN format with the PSTN. An interworking unit receives the control message, and in response, exchanges the telephony communications in the packet format with the user device and exchanges the telephony communications in the PSTN format with the selected PSTN connection.

20 Claims, 11 Drawing Sheets



U.S. PATENT DOCUMENTS

6,424,652	B1	7/2002	Christie	
6,490,273	B1	12/2002	DeNap et al.	
6,600,733	B2	7/2003	Deng	
6,829,234	B1	12/2004	Kaplan et al.	
6,993,011	B1 *	1/2006	Kaplan et al.	370/352
2002/0097708	A1	7/2002	Deng	

* cited by examiner

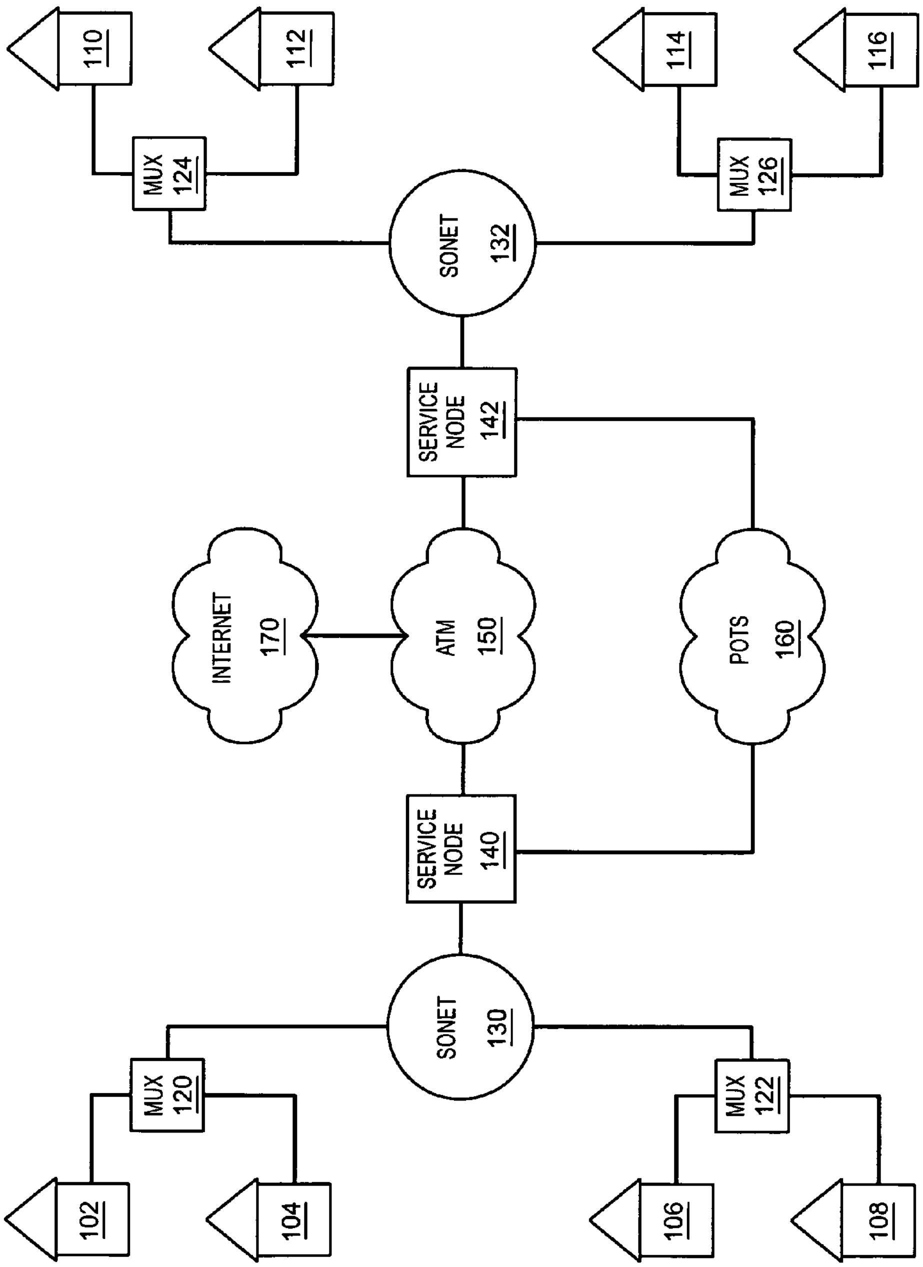

110
112
114
116
MUX 124
MUX 126
SONET 132
SERVICE NODE 142
INTERNET 170
ATM 150
POTS 160
SERVICE NODE 140
SONET 130
MUX 120
MUX 122
102
104
106
108

FIG. 1

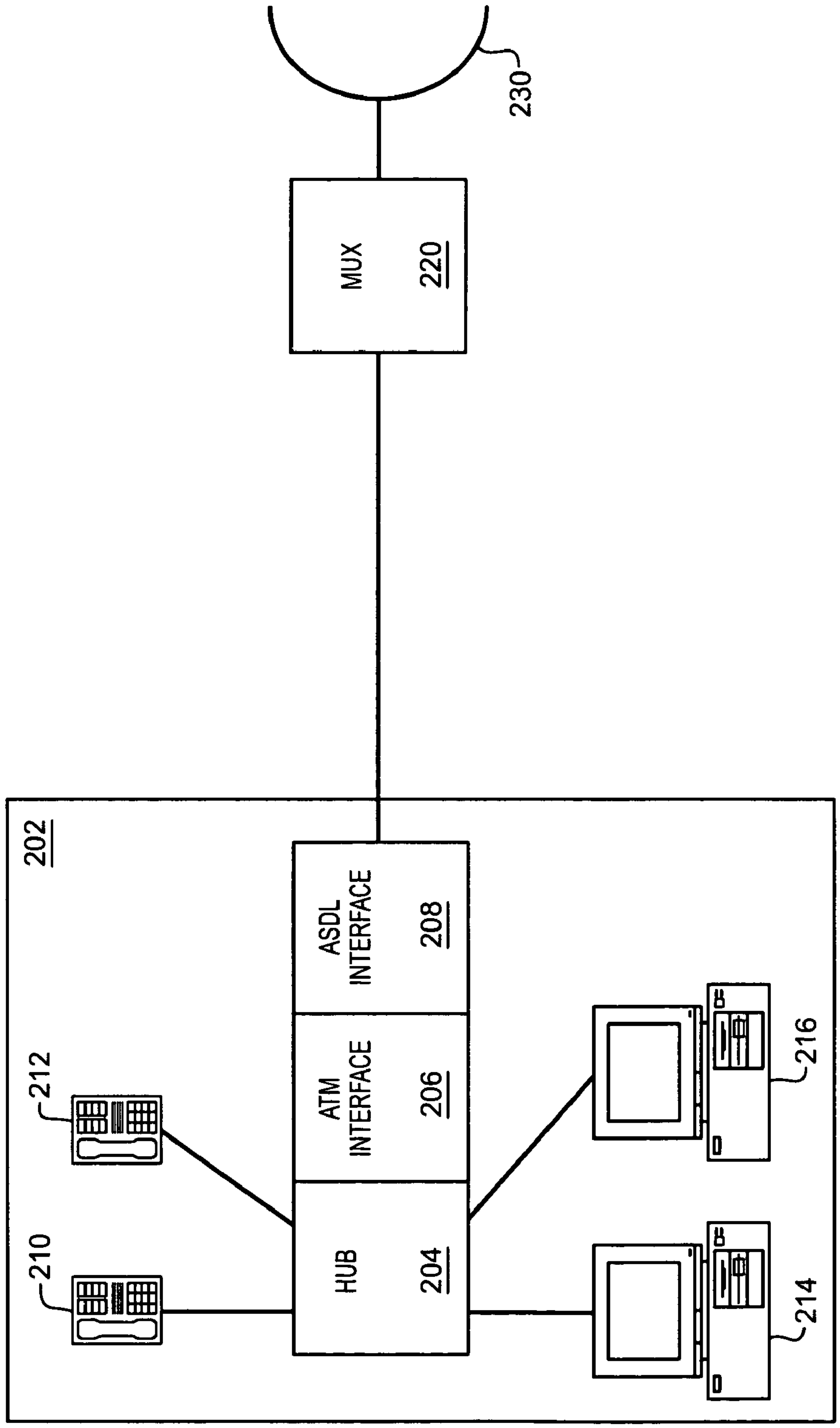

230
MUX
220
202
ASDL
INTERFACE
208
ATM
INTERFACE
206
HUB
204
210
212
214
216

FIG. 2

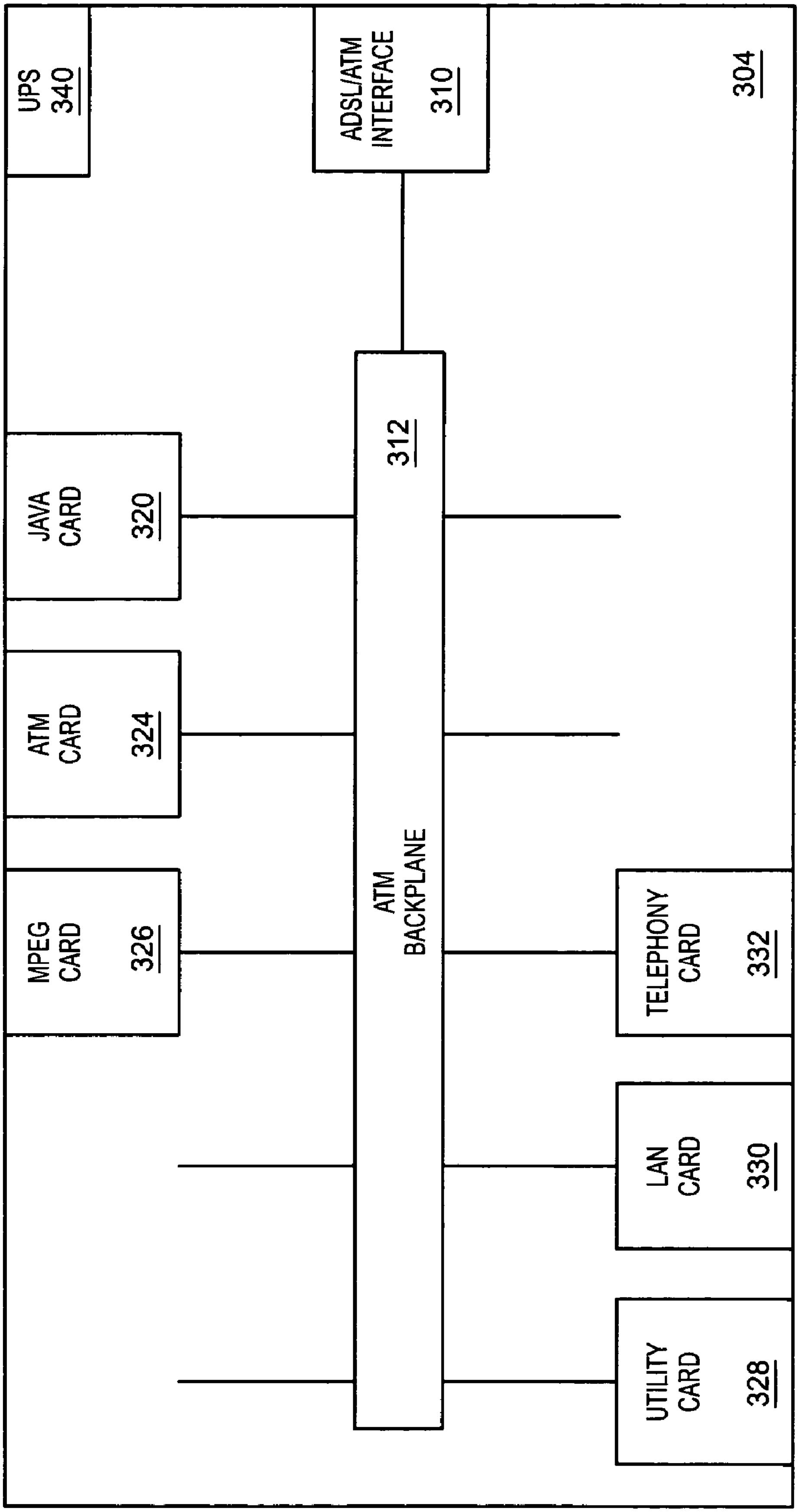

UPS
340
ADSL/ATM
INTERFACE
310
304
312
JAVA
CARD
320
ATM
CARD
324
MPEG
CARD
326
ATM
BACKPLANE
TELEPHONY
CARD
332
LAN
CARD
330
UTILITY
CARD
328

FIG. 3

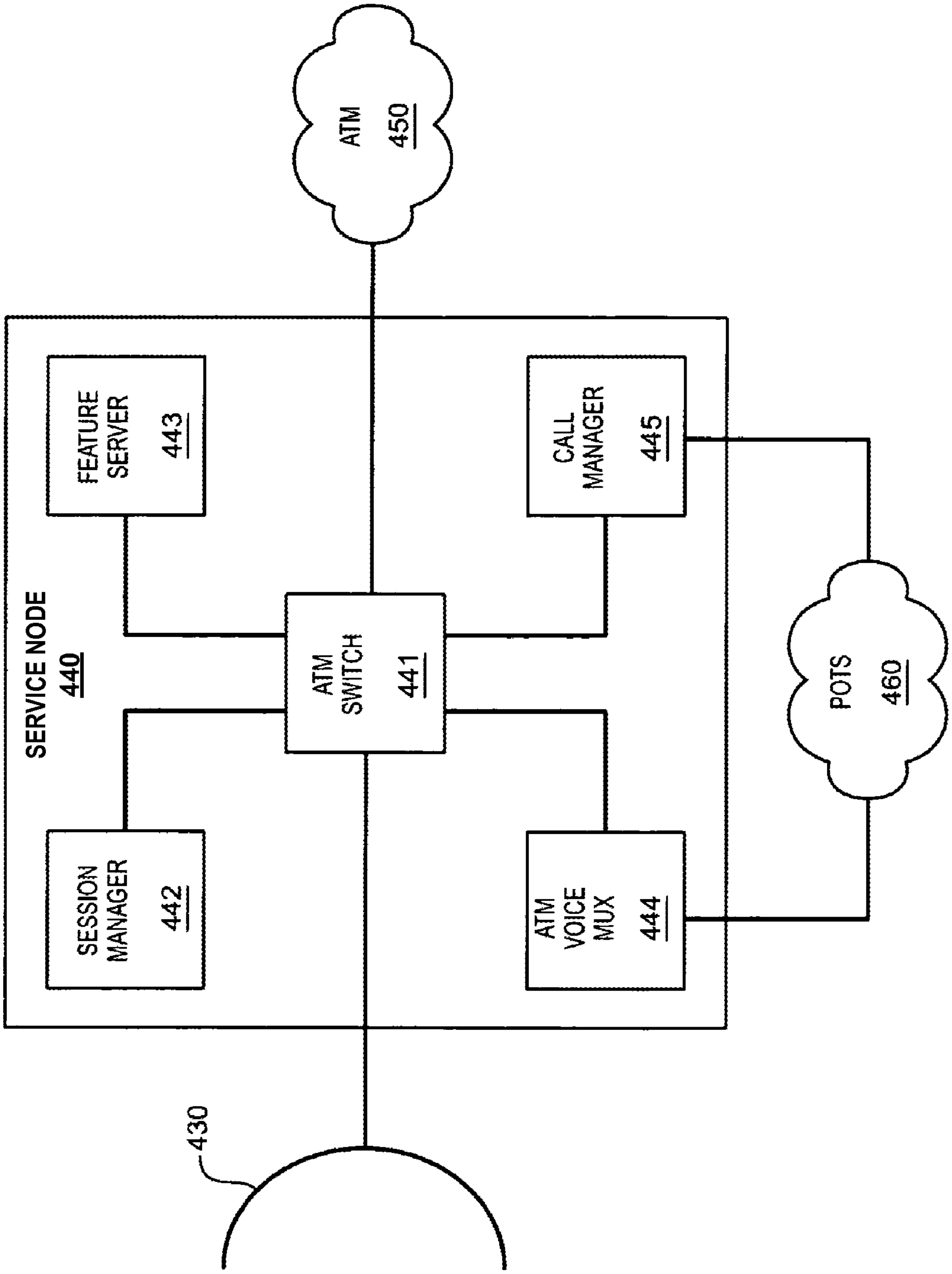

ATM 450
SERVICE NODE 440
FEATURE SERVER 443
CALL MANAGER 445
ATM SWITCH 441
SESSION MANAGER 442
ATM VOICE MUX 444
POTS 460
430

FIG. 4

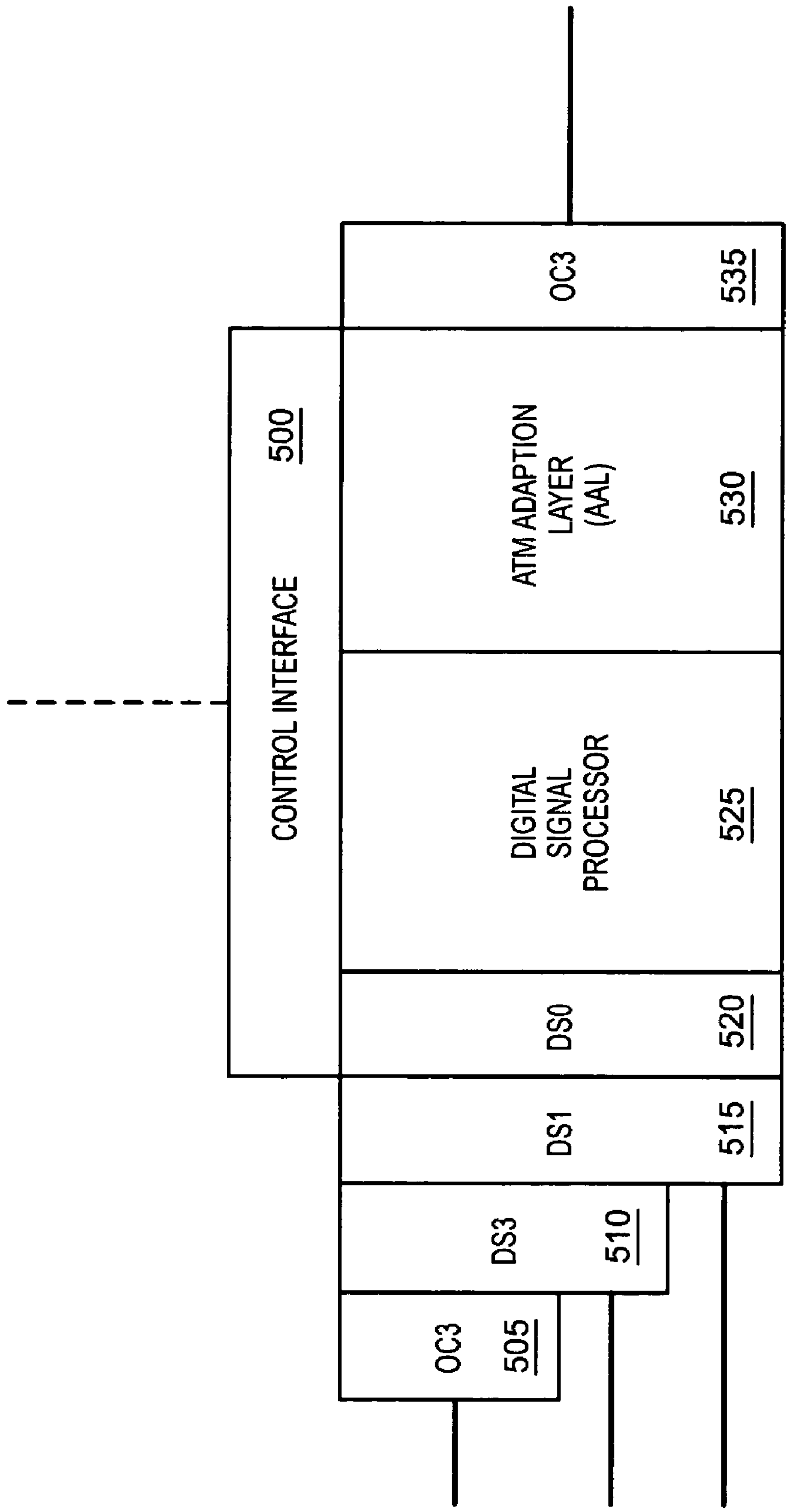

CONTROL INTERFACE
500
OC3
535
ATM ADAPTION LAYER (AAL)
530
DIGITAL SIGNAL PROCESSOR
525
DS0
520
DS1
515
DS3
510
OC3
505

FIG. 5

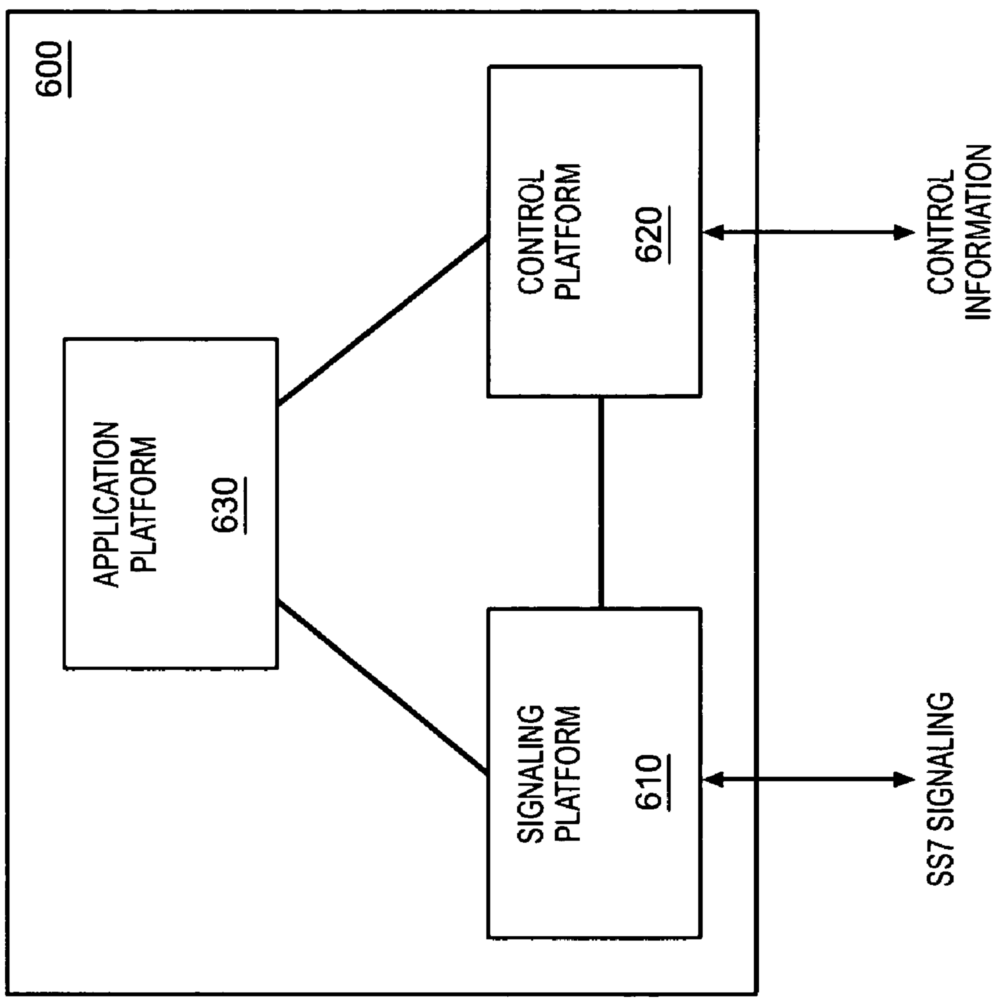

600
APPLICATION PLATFORM
630
CONTROL PLATFORM
620
SIGNALING PLATFORM
610
CONTROL INFORMATION
SS7 SIGNALING

FIG. 6

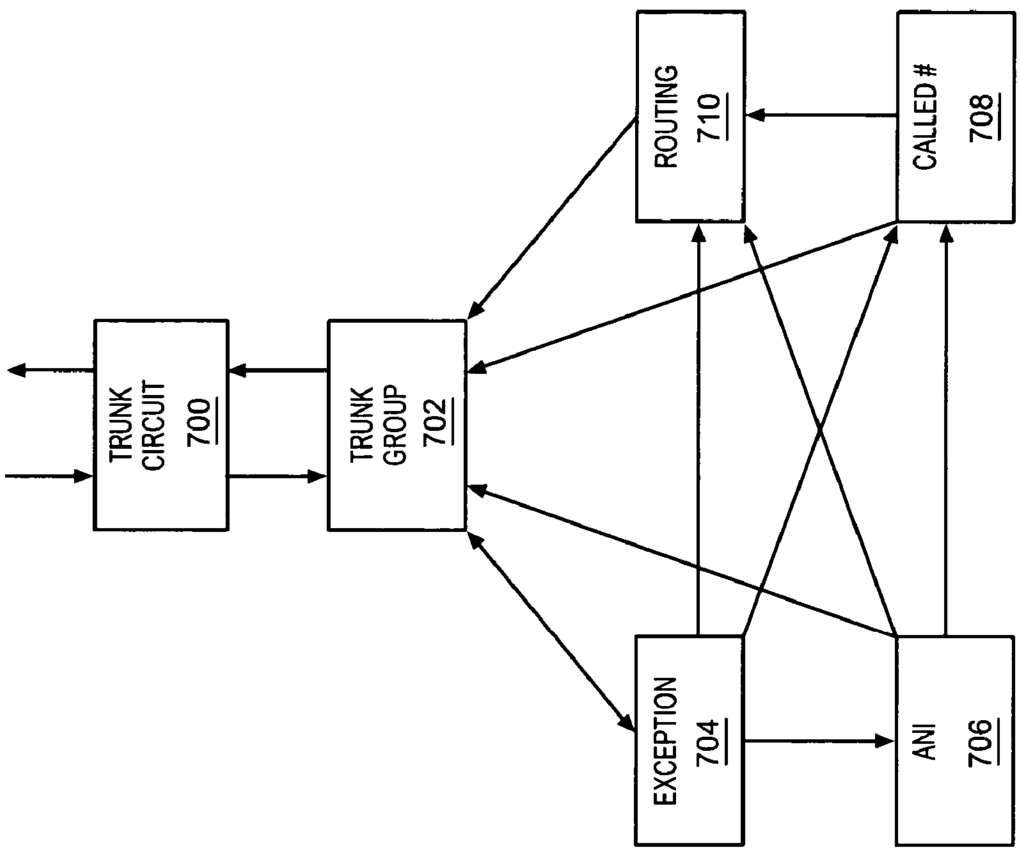

TRUNK CIRCUIT 700
TRUNK GROUP 702
EXCEPTION 704
ANI 706
CALLED # 708
ROUTING 710

FIG. 7

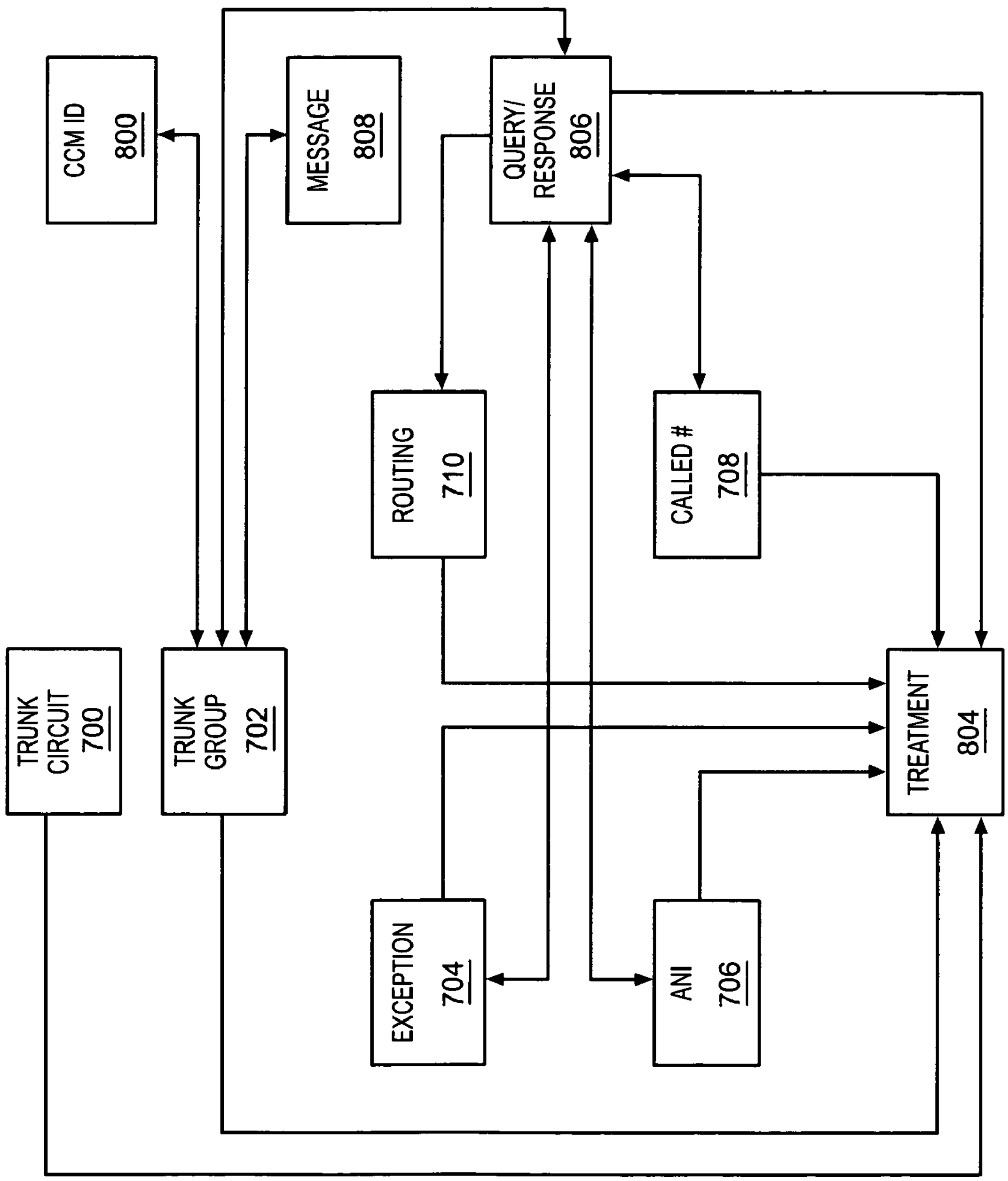

CCM ID
800
MESSAGE
808
QUERY/
RESPONSE
806
ROUTING
710
CALLED #
708
TRUNK
CIRCUIT
700
TRUNK
GROUP
702
TREATMENT
804
EXCEPTION
704
ANI
706

FIG. 8

ASSOCIATED POINT CODE	CIC	VP	VC	TRUNK GROUP NUMBER	GROUP MEMBER NUMBER	HARDWARE IDENTIFIER	ECHO CANCELLER	ECHO CONTROL	SATELLITE INDICATOR	CIRCUIT STATUS	CIRCUIT STATE	TIME/ DATE

FIG. 9

TRUNK GROUP NUMBER	GLARE RESOLUTION	CONTINUITY CONTROL	CLLI	SATELLITE TRUNK GROUP	SERVICE INDICATOR	ASSOCIATED NPA	SELECTION SEQUENCE	HOP COUNTER	ACC ACTIVE	OMI	NEXT FUNCTION	INDEX

FIG. 10

EXCEPTION TABLE INDEX	CARRIER SELECTION IDENTIFICATION	CARRIER IDENTIFICATION	CALLED PARTY			NEXT FUNCTION	INDEX
			NATURE OF ADDRESS	DIGITS FROM	DIGITS TO		

FIG. 11

ANI TABLE INDEX	CALLING PARTY CATEGORY	NATURE OF ADDRESS	CALLING PARTY/CHARGE NUMBER			ORIGINATING LINE INFORMATION	NEXT FUNCTION	NEXT INDEX
			DIGITS FROM	DIGITS TO	DATA			

FIG. 12

CALLED NUMBER TABLE INDEX	NATURE OF ADDRESS	DIGITS FROM	DIGITS TO	NEXT FUNCTION	NEXT INDEX

FIG. 13

ROUTING TABLE INDEX	TRANSIT NETWORK SELECTION			CIRCUIT CODE	NEXT FUNCTION #1	INDEX #1	NEXT FUNCTION #2	INDEX #2	NEXT FUNCTION #3	INDEX #3
	NETWORK IDENTIFICATION PLAN	DIGITS FROM	DIGITS TO							

FIG. 14

INDEX	MESSAGE RECEIVED CAUSE VALUE	GENERAL LOCATION	CODING STANDARD	CAUSE VALUE	NEXT FUNCTION	INDEX

FIG. 15

FIG. 16

MESSAGE TYPE	PARAMETERS	INDEX #1	INDEX #...	INDEX #N
ADDRESS COMPLETE	BACKWARD CALL INDICATOR			
	ACCESS TRANSPORT			
	CAUSE INDICATOR			
	OPTIONAL BACKWARD CALL INDICATORS			
	OPTIONAL "FE" INDICATOR			
ANSWER	ACCESS TRANSPORT			
	BACKWARD CALL INDICATOR			
CALL PROGRESS	EVENT INFORMATION			
	BACKWARD CALL INDICATOR			
	ACCESS TRANSPORT			
	CAUSE INDICATOR			
	OPTIONAL BACKWARD CALL INDICATOR			
CIRCUIT RESERVATION	NATURE OF CONNECTION INDICATOR			
CIRCUIT RESERVATION ACK	N/A			
CONFUSION	N/A			
CONTINUITY	CONTINUITY INDICATOR			
EXIT	OUTGOING TRUNK GROUP NUMBER			
INFORMATION	ALL PARAMETERS			
INFORMATION REQUEST	ALL PARAMETERS			
INITIAL ADDRESS	NATURE OF CONNECTION INDICATOR			
	FORWARD CALL INDICATOR			
	CALLING PARTY'S CATEGORY			
	USER SERVICE INFORMATION			
	CALLED PARTY NUMBER			
	ACCESS TRANSPORT			
	CALLING PARTY NUMBER			
	CARRIER IDENTIFICATION			
	CARRIER SELECTION INFORMATION			
	CHARGE NUMBER			
	GENERIC ADDRESS			
	ORIGINATING LINE INFORMATION			
	ORIGINAL CALLED NUMBER			
	REDIRECTING NUMBER			
	SERVICE CODE			
	TRANSIT NETWORK SELECTION			
	HOP COUNTER			
PASS ALONG	ALL PARAMETERS			
RELEASE	CAUSE INDICATOR			
	ACCESS TRANSPORT			
	AUTOMATIC CONGESTION CONTROL			
RELEASE COMPLETE	N/A			
RESUME	SUSPEND/RESUME INDICATOR			
SUSPEND	SUSPEND/RESUME INDICATOR			

TELECOMMUNICATIONS SYSTEM TO PROVIDE ANALOG TELEPHONY COMMUNICATIONS OVER A PACKET CONNECTION

RELATED APPLICATIONS

This patent application is a continuation of patent application Ser. No. 09/650,560, filed on Aug. 30, 2000, and entitled "Telecommunications System;" which is a continuation of patent application Ser. No. 08/826,641, filed on Apr. 4, 1997, and entitled "Telecommunications System." Both of these patent applications are hereby incorporated by reference into this patent application.

FEDERALLY SPONSORED RESERCH OR DEVELOPMENT

Not applicable

MICROFICHE APPENDIX

Not applicable

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to telecommunications systems, and in particular, to telecommunications systems that provides simultaneous voice and broadband services over ATM connections over the local loop.

2. Description of the Prior Art

The telephone wires to the residence are known as the local loop. The local loop has primarily been used to carry POTS traffic and low speed data using modems. POTS is an acronym for "Plain Old Telephone Service" and generally entails voice traffic. Digital Subscriber Line (DSL) technology has been developed to provide greater bandwidth to the local loop. DSL technology superimposes high bandwidth data over the analog POTS traffic on the local loop. This high bandwidth data is transparent to the POTS operation of the local loop. At the central office, the high bandwidth data is removed from the twisted pair and provided to a separate data network. The POTS traffic remains on the twisted pair and is provided to a class 5 switch. As a result, DSL technology allows high bandwidth data and POTS traffic to co-exist on the local loop. POTS traffic is still handled by a class 5 switch in the conventional manner, but the high bandwidth data is removed from the line before the class 5 switch.

Asynchronous Transfer Mode (ATM) and Synchronous Optical Network (SONET) technologies have also been developed to provide broadband transport and switching capability to Local Area Networks (LANs), Wide Area Networks (WANs), and other networks. Prior systems do not contemplate converting the voice traffic to ATM before it is placed on the DSL local loop. This is because standard class 5 switches on the network side of the local loop do not typically handle ATM voice traffic. As a result, ATM technology has not been combined with DSL technology to carry residential POTS traffic. POTS traffic carried by a DSL local loop still requires processing by a complex and expensive class 5 switch.

SUMMARY OF THE INVENTION

A communication system provides PSTN access to a user device coupled to a packet network over a packet connection. The user device exchanges telephony signaling and telephony communications in an analog format with an analog telephone, exchanges the telephony signaling and the telephony communications in the packet format over the packet connection, and exchanges Internet communications over the packet connection. A service node exchanges the telephony signaling in the packet format with the user device, processes the telephony signaling to select a PSTN connection, transfers a control message indicating the PSTN connection, and exchanges the telephony signaling in a PSTN format with the PSTN. An interworking unit receives the control message, and in response, exchanges the telephony communications in the packet format with the user device and exchanges the telephony communications in the PSTN format with the selected PSTN connection.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

FIG. **1** is a block diagram of a version of the invention.

FIG. **2** is a block diagram of a version of the residence.

FIG. **3** is a block diagram of a version of the residential hub.

FIG. **4** is a block diagram of a version of the service node.

FIG. **5** is a message sequence chart of a version of the invention.

FIG. **6** is a block diagram of a version of the invention.

FIG. **7** is a logic diagram of a version of the invention.

FIG. **8** is a logic diagram of a version of the invention.

FIG. **9** is a logic table used in a version of the invention.

FIG. **10** is a logic table used in a version of the invention.

FIG. **11** is a logic table used in a version of the invention.

FIG. **12** is a logic table used in a version of the invention.

FIG. **13** is a logic table used in a version of the invention.

FIG. **14** is a logic table used in a version of the invention.

FIG. **15** is a logic table used in a version of the invention.

FIG. **16** is a logic table used in a version of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The invention combines ATM technology with class 5 switch emulation to provide bandwidth, class 5 features, and other services over the local loop. In preferred embodiments, Asymmetrical Digital Subscriber Line (ADSL) technology is used to transport ATM over the local loop. In ADSL, conventional voice traffic (POTS) and high bandwidth data traffic can co-exist on the local loop. Currently, ADSL can typically support 6,000,000 bits per second into the residence and 500,000 bits per second out of the residence. For comparison, a conventional telephone conversation requires 64,000 bits per second.

FIG. **1** depicts a system for some embodiments of the invention, although one skilled in the art will appreciate other variations and implementations covered by the claims. Shown are residences **102**, **104**, **106**, **108**, **110**, **112**, **114**, and **116**. Residences **102** and **104** are connected to mux **120**. Residences **106** and **108** are connected to mux **122**. Residences **110** and **112** are connected to mux **124**. Residences **114** and **116** are connected to mux **126**. The residences are connected to the muxes over ATM connections, and in preferred embodiments, these connections are ADSL/ATM connections. Muxes **120** and **122** are connected to SONET ring **130**. Service node **140** is also connected to SONET ring **130**. Muxes **124** and **126** are connected to SONET ring **132**. Service node **142** is also connected to SONET ring **132**. Both

service nodes **140** and **142** are connected to ATM network **150** and to POTS network **160**. ATM network **150** is connected to internet **170**.

The residences have end users who desire communications services. The residences are depicted as homes, but they could also be businesses or other sites where users desire communications services. Typically, the end users operate telephones, computers, fax machines, televisions, and other communications devices. The residences exchange ATM communications with the muxes over the local loops. In preferred embodiments, the residences and the muxes communicate with each other over the local loop using DSL interfaces. In other embodiments, the connections could be ATM carried over wireless links or other high speed connections. The residences also have ATM interfaces that can interwork between end user communications and ATM.

It is important to point out that the invention converts POTS traffic to ATM traffic at the residence, and preferably carries this ATM traffic over an ADSL connection to the mux. The invention also converts non-voice traffic to ATM traffic, and preferrably carries this additional ATM traffic over the DSL connection to the mux. This represents a distinct advance in the art. DSL technology treats POTS in the conventional manner by providing POTS traffic to a class 5 switch.

The muxes have ATM/SONET interfaces to communicate over the SONET rings. In preferred embodiments, the muxes interwork between ADSL connections from the residences and SONET connections to the service nodes. Thus, communications between the residence and the mux are preferably carried over ADSL/ATM connections, and communications between the mux and the service node are preferably carried over SONET/ATM connections. The mux converts between ADSL/ATM and SONET/ATM.

The muxes also have the ability to implement ATM Switched Virtual Circuits (SVCs). Essentially, this means that muxes can interwork ATM cells streams between different virtual connections upon request. This allows various connection options between a residence and a service node. ATM connections could be provisioned as PVC/PVCs from the residence directly to the service node. This tends to waste bandwidth in the SONET rings. ATM connections could be provisioned from the residence to the mux, and the mux and service node could use SVCs to communicate. The entire connection between the residence and the service node could establish SVCs as needed. In addition, combinations of the above could be provided. For example, low bandwidth control channels could be provisioned directly from residence to service node, but higher bandwidth bearer channels could be established on an SVC basis.

The SONET rings provide broadband transport pipes that carry ATM cells. Preferably, the SONET rings are broadband metropolitan area network (B-MAN) rings that serve dense residential and commercial areas. The SONET rings may include ATM switches, including ATM switches that provide the muxes with access to the SONET rings. SONET rings can be self-healing. If a self-healing ring is cut, connectivity is maintained as communications may be transported in the other direction around the ring to bypass the cut. SONET connections are typically provisioned from endpoint to endpoint. The muxes have SONET connections provisioned through the rings to the service nodes. The muxes and service nodes communicate over these ATM/SONET connections.

The service nodes provide an interface between the end users and many communications services and features. The end users communicate with the service nodes to specify end-user communication service requirements. The service nodes then instruct the communications networks to deliver the required services to the end users. It can be seen that the end user communications are converted to ATM at the residence and provided to the service nodes as ATM traffic. This includes POTS traffic. As a result, the residence and service node can support POTS voice over ATM without using a class 5 switch.

ATM network **150** interconnects the various service nodes. Typically, ATM network **150** is a SONET/ATM system comprised of ATM cross-connects and SONET Add Drop Multiplexers (ADMs). ATM network **150** also provides access to internet **170**. Internet **170** could be the conventional "Internet" that uses the TCP/IP protocol. The service nodes are also connected to POTS network **160**. POTS network **160** is the conventional "Plain Old Telephone Service" that primarily carries telephone voice traffic.

To illustrate the operation of the system depicted in FIG. **1**, a few examples will be discussed. One skilled in the art will appreciate that numerous other examples could also be supported by the invention. Consider that an end user at residence **104** may request a telephone conversation with another end user at residence **116**. Since both end users are coupled to service nodes, this is an "on-net" call. Residence **104** will send a call request through mux **120** and SONET ring **130** to service node **140**. Typically, a provisioned ATM control channel will be used during set-up. Service node **140** will identify the request as on-net and set-up an ATM path between residence **104** and residence **116**. This ATM path will utilize mux **120**, SONET ring **130**, service node **140**, ATM network **150**, service node **142**, SONET ring **132**, and mux **126**. Typically, ATM PVCs are provisioned between the residences and the muxes, and ATM SVCs are used on the network side of the muxes.

Another end user at residence **104** may desire a telephone conversation with an entity not coupled to a service node. This "off-net" call would be set-up by service node **140** through POTS network **160**. Yet another end-user at residence **104** may desire access to internet **170**. Service node **140** will accept this request and set-up the connection to internet **170** through mux **120**, SONET ring **130**, and ATM network **150**. Because of the high bandwidth available with ATM over ADSL and SONET, all three of these communication sessions could occur simultaneously.

FIG. **2** depicts an example of a residence in some embodiments of the invention. Where applicable, the reference numbers for components that are similar retain the same final two digits from one figure to the next. Within residence **202** are hub **204**, ATM interface **206**, ADSL modem **208**, telephone **210**, telephone **212**, computer **214**, and computer **216**. The telephones and computers are connected to hub **204** over conventional connections. Hub **204** is coupled to ATM interface **206** which is coupled to ADSL modem **208**. ADSL modem **206** is connected to mux **220**, which is connected to SONET ring **230**.

Hub **204** has an analog telephony interface that supports analog telephony communications with the telephones. Hub **204** provides dial tone and power to the telephones. Hub **204** can detect on-hook and off-hook conditions as well as DTMF tones. Hub **204** can also provide ringback and busy tones to the telephones. Each telephone could have its own line or could share lines. Hub **204** communicates with the service node to set-up communications sessions for the telephones.

Hub **204** also provides a LAN/router function to the computers. For example, hub **204** could be equipped with an ethernet interface for connection to the computers. When a communications request is made by one of the computers, hub **204** routes the request to the service node. ATM interface **206** can integrate voice, video, and data over high-bandwidth

ATM connections for the telephones and computers. ATM interface **206** provides ATM cells to ADSL modem **206** for transport to mux **220**. Mux **220** is connected to SONET ring **230**. Conventional requirements for hub **204** can be found in Telecommunications Industry Association (TIA) document SP-3771.

FIG. **3** depicts an example of the residential components of some embodiments of the invention. Shown is hub **304** and it includes ADSL/ATM interface **310** and ATM backplane **314**. Together, these components allow for ATM communications within the hub and with external elements through ADSL/ATM interface **310**. ADSL/ATM interface **310** converts end user control and communications into the ADSL/ATM format for transport to the service node. ATM/ADSL interface **310** also receives communications and control from the service node and provides these to the appropriate components of hub **304**. ADSL/ATM **310** interface also provides smoothing and shaping for the ATM signals.

Also shown are several cards connected to ATM backplane **314**. These are: Java card **320**, ATM card **324**, MPEG card **326**, utility card **328**, LAN card **330**, and telephony card **332**. The cards provide communications services to the end users as discussed below. The cards can communicate with each other or through ATM backplane **314**. They can also communicate with the service node directly through interface **310**. An uninterruptible power supply (UPS) may be included if desired in order to provide power during an outage to the home.

Java card **320** includes a processor and memory and is operational to receive Java applets from the service node. Java applets can support a wide variety of tasks. In particular, Java applets can be used to provide the intelligence to support class 5 features, such as call waiting and call forwarding. Java card **320** also exerts control over the cards and ADSL/ATM interface **310**. This could include ATM virtual connection assignments for communications to the mux or service node. Java card **320** may also communicate with the service node to request numerous other communications services.

ATM card **324** provides an ATM interface to devices within the residence. If ATM card **324** exchanges ATM signaling with resident devices over VPI=0 and VPI=5, then ATM card **325** may use virtual path associated signaling to exchange control information with the service node. MPEG card **326** provides an MPEG interface to devices within the residence. MPEG is a video formatting standard. Typically, MPEG card **326** will receive MPEG formatted video in ATM cells through ADSL/ATM interface **310** and provide video signals to devices in the residence. Utility card **328** is a card that is couple to utility metering devices in the home. The utility card is programmed to collect the metering information and forward it to the utility companies through ADSL/ATM interface **310**. LAN card **330** supports a LAN that is internal to the residence. For, example, LAN card **330** could support ethernet connections to multiple computers. The computers could access the Internet through LAN card **330** and ADSL/ATM interface **310**.

Telephony card **332** supports analog telephony communications with the telephones. Telephony card **332** provides dial tone and power to the telephones. Telephony card **332** can detect on-hook and off-hook conditions as well as DTMF tones. Telephony card **332** can also provide ringback and busy tones to the telephones. In some embodiments, telephony card **332** provides echo cancellation or other digital signal processing functions. Telephony card **332** can forward control information (i.e. off-hook+dialed number) to the service node either directly through ADSL/ATM interface **310** or through Java card **320** and ADSL/ATM interface **310**.

FIG. **4** depicts an example of a service node for some embodiments of the invention. Shown is service node **440**. It comprises ATM switch **441**, session manager **442**, feature server **443**, ATM voice mux (AVM) **443** and public switched telephone network (PSTN) gateway **445**. ATM switch **441** is connected to SONET ring **430** and ATM network **450**. AVM **444** and Call Manager **445** are connected to POTS network **460**. ATM switch **441** is able to establish switched virtual circuits (SVCs) in response to control instructions from session manager **442**. Feature server **443** provides various features to the end users. Feature server **443** may provide class 5 features to end users. Feature server **443** may download software or Java applets to the residential hub. Feature server could provide other features, such as intranets, voice mail, or personalized internet web pages and browsers.

Session manager **442** is a communications control processor that initiates services for the end users. Session manager **442** is compliant with the Telecommunications Information Network Architecture Consortium (TINA-C) requirements. It houses the user agent and the residential hub houses the provider agent. Together, the user agent and the provider agent communicate to establish requirements for a communications service. One requirement is quality of service and it typically entails bandwidth, priority, as well as other factors. The session manager issues control messages to the required elements to deliver the communications service.

The combination of the provider agent and session manager provides numerous incoming call management capabilities. Based on these capabilities, the users can establish their own preferences and policies. If a single phone number is assigned to all the phones, then one policy for handling incoming calls would be to ring all the idle phones. When one of the phones is answered, the call is routed to that phone and the ringing is stopped at the other phones. Another policy would be that a particular idle phone is selected for ringing. The selection could also be based on any number of inputs such as the caller identity, time of day, day of week, etc. In general, a very flexible association between phone numbers and assigned telephone lines can be created. There can be one phone number per line, or there can be more phone numbers than lines with distinctive ringing based on the called number.

If the user has a personal computer with an HTML browser, the user can access a network service that can allow the user to create a personalized set of call management rules that control communications with the user. This would be achieved via a graphical application where the user creates a decision tree by putting components together on a palette. This information would be distributed between the session manager and the provider agent. For example, the session manager would know which calls to route to voice mail based on the caller's identity. For such a call, the provider agent will not need to get a call message from session manager. On the other hand, the logic discussed above that handles which phone(s) to alert will be encapsulated in the provider agent.

AVM **444** provides a bearer channel interface between POTS network **460** and ATM switch **441**. Typically, the requires interworking DS0 connections with ATM virtual connections. Call Manager **445** provides a call processor and SS7 signaling interface between POTS network **460** and session manager **442** (through ATM switch **441**). Typically, this requires processing session manager requests and generating SS7 messages for POTS network **460**. In addition, SS7 messages from POTS network **460** are received and processed by Call manager **460**, and control information is passed to session manager **442**.

FIG. **5** shows one embodiment of the mux that is suitable for the present invention, but other muxes that support the

requirements of the invention are also applicable. Shown are control interface **500**, OC-3 interface **505**, DS3 interface **510**, DS1 interface **515**, DS0 interface **520**, digital signal processor **525**, ATM adaption Layer (AAL) **530**, and OC-3 interface **535**.

Control interface **500** accepts messages from the call manager. In particular, control interface **500** provides DS0/virtual connection assignments to AAL **530** for implementation. Control interface **500** may accept control messages from the call manager with messages for DS0 **520**. These messages could be to connect DS0s to: 1) other DS0s, 2) digital signal processor **525**, or 3) AAL **530** (bypassing digital signal processor **525**). Control interface **500** may accept control messages from the call manager with messages for digital signal processing **525**. An example of such an message would be to disable an echo canceller on a particular connection.

OC-3 interface **505** accepts the OC-3 format and makes the conversion to DS3. DS3 interface **510** accepts the DS3 format and makes the conversion to DS1. DS3 interface **510** can accept DS3s from OC-3 interface **505** or from an external connection. DS1 interface **515** accepts the DS1 format and makes the conversion to DS0. DS 1 interface **515** can accept DS Is from DS3 interface **510** or from an external connection. DS0 interface **520** accepts the DS0 format and provides an interface to digital signal processor **525** or AAL **530**. In some embodiments, DS0 interface **520** could be capable of directly interconnecting particular DS0s. This could be the case for call entering and egressing from the same mux. This would also be useful to facilitate continuity testing by a switch. OC-3 interface **535** is operational to accept ATM cells from AAL **530** and transmit them, typically over the connection to the ATM switch in the service node.

Digital signal processor **525** is operational to apply various digital processes to particular DS0s in response to control messages received through control interface **500**. Examples of digital processing include: tone detection, tone transmission, loopbacks, voice detection, voice messaging, echo cancellation, compression, and encryption. In some embodiments, digital signal processing **525** could handle continuity testing. For example, the call manager may instruct the mux to provide a loopback for a continuity test and or disable cancellation for a call. Digital signal processor **525** is connected to AAL **530**. As discussed, DS0s from DS0 interface **520** may bypass digital signal processing **525** and be directly coupled to AAL **530**.

AAL **530** comprises both a convergence sublayer and a segmentation and reassembly (SAR) layer. AAL **530** is operational to accept the user information in DS0 format from DS0 interface **520** or digital signal processor **525** and convert the information into ATM cells. AALs are known in the art and information about AALs is provided by International Telecommunications Union (ITU) document I.363. An AAL for voice is also described in patent application Ser. No. 08/395,745, filed on Feb. 28, 1995, entitled "Cell Processing for Voice Transmission", and hereby incorporated by reference into this application. AAL **530** obtains the virtual path identifier (VPI) and virtual channel identifier (VCI) for each call from control interface **500**. AAL **530** also obtains the identity of the DS0 for each call (or the DS0s for an Nx64 call). AAL **530** then converts user information between the identified DS0 and the identified ATM virtual connection. Acknowledgments that the assignments have been implemented may be sent back to the call manager if desired. Calls with a bit rate that are a multiple of 64 kbit/second are known as Nx64 calls. If desired, AAL **530** can be capable of accepting control messages through control interface **500** for Nx64 calls.

As discussed above, the mux also handles calls in the opposite direction—from OC-3 interface **535** to DS0 interface **520**. Control interface **500** will provide AAL **530** with the assignment of the selected VPI/VCI to the selected outbound DS0. The mux will convert the ATM cells with the selected VPI/VCI in the cell headers into the DS0 format and provide it to the selected outbound DS0 connection.

A technique for processing VPI/VCIs is disclosed in patent application Ser. No. 08/653,852, filed on May 28, 1996, entitled "Telecommunications System with a Connection Processing System," and hereby incorporated by reference into this application.

The call manager is a signaling processor that is referred to as a call/connection manager (CCM), and it receives and processes telecommunications call signaling and control messages to select connections that establish communication paths for calls. In the preferred embodiment, the CCM processes SS7 signaling to select connections for a call. CCM processing is described in a U.S. patent application, having attorney docket no. 1148, which is entitled "Telecommunication System," which is assigned to the same assignee as this patent application, and which is incorporated herein by reference.

In addition to selecting connections with the POTS network, the CCM performs many other functions in the context of call processing. It not only can control routing and select the actual connections, but it can also validate callers, control echo cancellers, generate billing information, invoke intelligent network functions, access remote databases, manage traffic, and balance network loads. One skilled in the art will appreciate how the CCM described below can be adapted to operate in the above embodiments.

FIG. **6** depicts a version of the CCM. Other versions are also contemplated. In the embodiment of FIG. **6**, CCM **600** controls an ATM interworking multiplexer (mux) that performs interworking of DS0s and VPI/VCIs. However, the CCM may control other communications devices and connections in other embodiments.

CCM **600** comprises signaling platform **610**, control platform **620**, and application platform **630**. Each of the platforms **610**, **620**, and **630** is coupled to the other platforms.

Signaling platform **610** is externally coupled to the SS7 systems—in particular to systems having a message transfer part (MTP), an ISDN user part (ISUP), a signaling connection control part (SCCP), an intelligent network application part (INAP), and a transaction capabilities application part (TCAP). Control platform **620** is externally coupled to a mux control, an echo control, a resource control, billing, and operations.

Signaling platform **610** comprises MTP levels 1-3, ISUP, TCAP, SCCP, and INAP functionality and is operational to transmit and receive the SS7 messages. The ISUP, SCCP, INAP, and TCAP functionality use MTP to transmit and receive the SS7 messages. Together, this functionality is referred as an "SS7 stack," and it is well known. The software required by one skilled in the art to configure an SS7 stack is commercially available, for example, from the Trillium company.

Control platform **620** is comprised of various external interfaces including session manager interface, a mux interface, an echo interface, a resource control interface, a billing interface, and an operations interface. The mux interface exchanges messages with at least one mux. These messages comprise DS0 to VPI/VCI assignments, acknowledgments, and status information. The echo control interface exchanges messages with echo control systems. Messages exchanged with echo control systems might include instructions to

enable or disable echo cancellation on particular DS0s, acknowledgments, and status information.

The resource control interface exchanges messages with external resources via the session manager. Examples of such resources are devices that implement continuity testing, encryption, compression, tone detection/transmission, voice detection, and voice messaging. The messages exchanged with resources are instructions to apply the resource to particular DS0s, acknowledgments, and status information. For example, a message may instruct a continuity testing resource to provide a loopback or to send and detect a tone for a continuity test.

The billing interface transfers pertinent billing information to a billing system. Typical billing information includes the parties to the call, time points for the call, and any special features applied to the call. The operations interface allows for the configuration and control of CCM **600**. One skilled in the art will appreciate how to produce the software for the interfaces in control platform **620**.

Application platform **630** is functional to process signaling information from signaling platform **610** in order to select connections. The identity of the selected connections are provided to control platform **620** for the mux interface. Application platform **630** is responsible for validation, translation, routing, call control, exceptions, screening, and error handling. In addition to providing the control requirements for the mux, application platform **630** also provides requirements for echo control and resource control to the appropriate interface of control platform **620**. In addition, application platform **630** generates signaling information for transmission by signaling platform **610**. The signaling information might be ISUP, INAP, or TCAP messages to external network elements. Pertinent information for each call is stored in a call control block (CCB) for the call. The CCB can be used for tracking and billing the call.

Application platform **630** operates in general accord with the Basic Call Model (BCM) defined by the ITU. An instance of the BCM is created to handle each call. The BCM includes an originating process and a terminating process. Application platform **630** includes a service switching function (SSF) that is used to invoke the service control function (SCF). Typically, the SCF is contained in a service control point (SCP). The SCF is queried with TCAP or INAP messages. The originating or terminating processes will access remote databases with intelligent network (IN) functionality via the SSF function.

Software requirements for application platform **630** can be produced in specification and description language (SDL) defined in ITU-T Z.100. The SDL can be converted into C code. Additional C and C++ code can be added as required to establish the environment.

From FIG. **6**, it can be seen that application platform **630** processes signaling information to control numerous systems and facilitate call connections and services. The SS7 signaling is exchanged with external components through signaling platform **610**, and control information is exchanged with external systems through control platform **620**. Advantageously, CCM **600** is not integrated into a switch CPU that is coupled to a switching matrix. Unlike an SCP, CCM **600** is capable of processing ISUP messages independently of TCAP queries.

SS7 messages are well known. Designations for various SS7 messages commonly are used. Those skilled in the art are familiar with the following message designations:

ACM—Address Complete Message
ANM—Answer Message
BLO—Blocking

BLA—Blocking Acknowledgment
CPG—Call Progress
CRG—Charge Information
CGB—Circuit Group Blocking
CGBA—Circuit Group Blocking Acknowledgment
GRS—Circuit Group Reset
GRA—Circuit Group Reset Acknowledgment
CGU—Circuit Group Unblocking
CGUA—Circuit Group Unblocking Acknowledgment
CQM—Circuit Group Query
CQR—Circuit Group Query Response
CRM—Circuit Reservation Message
CRA—Circuit Reservation Acknowledgment
CVT—Circuit Validation Test
CVR—Circuit Validation Response
CFN—Confusion
COT—Continuity
CCR—Continuity Check Request
EXM—Exit Message
INF—Information
INR—Information Request
IAM—Initial Address
LPA—Loop Back Acknowledgment
PAM—Pass Along
REL—Release
RLC—Release Complete
RSC—Reset Circuit
RES—Resume
SUS—Suspend
UBL—Unblocking
UBA—Unblocking Acknowledgment
UCIC—Unequipped Circuit Identification Code.

Call processing typically entails two aspects. First, an incoming or "originating" connection is recognized by an originating call process. For example, the initial connection that a call uses to enter a network is the originating connection in that network. Second, an outgoing or "terminating" connection is selected by a terminating call process. For example, the terminating connection is coupled to the originating connection in order to extend the call through the network. These two aspects of call processing are referred to as the originating side of the call and the terminating side of the call.

FIG. **7** depicts a data structure used by application platform **630** of FIG. **6** to execute the BCM. This is accomplished through a series of tables that point to one another in various ways. The pointers are typically comprised of next function and next index designations. The next function points to the next table, and the next index points to an entry or a range of entries in that table. The data structure has trunk circuit table **700**, trunk group table **702**, exception table **704**, ANI table **706**, called number table **708**, and routing table **710**.

Trunk circuit table **700** contains information related to the connections. Typically, the connections are DS0 or ATM connections. Initially, trunk circuit table **700** is used to retrieve information about the originating connection. Later, the table is used to retrieve information about the terminating connection. When the originating connection is being processed, the trunk group number in trunk circuit table **700** points to the applicable trunk group for the originating connection in trunk group table **702**.

Trunk group table **702** contains information related to the originating and terminating trunk groups. When the originating connection is being processed, trunk group table **702** provides information relevant to the trunk group for the originating connection and typically points to exception table **704**.

Exception table **704** is used to identify various exception conditions related to the call that may influence the routing or

other handling of the call. Typically, exception table **704** points to ANI table **706**. Although, exception table **704** may point directly to trunk group table **702**, called number table **708**, or routing table **710**.

ANI table **706** is used to identify any special characteristics related to the caller's number. The caller's number is commonly known as automatic number identification (ANI). ANI table **706** typically points to called number table **708**. Although, ANI table **706** may point directly to trunk group table **702** or routing table **710**.

Called number table **708** is used to identify routing requirements based on the called number. This will be the case for standard telephone calls. Called number table **708** typically points to routing table **710**. Although, it may point to trunk group table **702**.

Routing table **710** has information relating to the routing of the call for the various connections. Routing table **710** is entered from a pointer in either exception table **704**, ANI table **706**, or called number table **708**. Routing table **710** typically points to a trunk group in trunk group table **702**.

When exception table **704**, ANI table **706**, called number table **708**, or routing table **710** point to trunk group table **702**, they effectively select the terminating trunk group. When the terminating connection is being processed, the trunk group number in trunk group table **702** points to the trunk group that contains the applicable terminating connection in trunk circuit table **702**. The terminating trunk circuit is used to extend the call. The trunk circuit is typically a VPI/VCI or a DS0. Thus it can be seen that by migrating through the tables, a terminating connection can be selected for a call.

FIG. **8** is an overlay of FIG. **7**. The tables from FIG. **7** are present, but for clarity, their pointers have been omitted. FIG. **8** illustrates additional tables that can be accessed from the tables of FIG. **7**. These include CCM ID table **800**, treatment table **804**, query/response table **806**, and message table **808**.

CCM ID table **800** contains various CCM SS7 point codes. It can be accessed from trunk group table **702**, and it points back to trunk group table **702**. Treatment table **804** identifies various special actions to be taken in the course of call processing. This will typically result in the transmission of a release message (REL) and a cause value. Treatment table **804** can be accessed from trunk circuit table **700**, trunk group table **702**, exception table **704**, ANI table **706**, called number table **708**, routing table **710**, and query/response table **806**.

Query/response table **806** has information used to invoke the SCF. It can be accessed by trunk group table **702**, exception table **704**, ANI table **706**, called number table **708**, and routing table **710**. It points to trunk group table **702**, exception table **704**, ANI table **706**, called number table **708**, routing table **710**, and treatment table **804**. Message table **808** is used to provide instructions for messages from the termination side of the call. It can be accessed by trunk group table **702** and points to trunk group table **702**.

FIGS. **9-16** depict examples of the various tables described above. FIG. **9** depicts an example of the trunk circuit table. Initially, the trunk circuit table is used to access information about the originating circuit. Later in the processing, it is used to provide information about the terminating circuit. For originating circuit processing, the associated point code is used to enter the table. This is the point code of the switch or CCM associated with the originating circuit. For terminating circuit processing, the trunk group number is used to enter the table.

The table also contains the circuit identification code (CIC). The CIC identifies the circuit which is typically a DS0 or a VPI/VCI. Thus, the invention is capable of mapping the SS7 CICs to the ATM VPI/VCI. If the circuit is ATM, the virtual path (VP) and the virtual channel (VC) also can be used for identification. The group member number is a numeric code that is used for terminating circuit selection. The hardware identifier identifies the location of the hardware associated with the originating circuit. The echo canceller (EC) identification (ID) entry identifies the echo canceller for the originating circuit.

The remaining fields are dynamic in that they are filled during call processing. The echo control entry is filled based on three fields in signaling messages: the echo suppresser indicator in the IAM or CRM, the echo control device indicator in the ACM or CPM, and the information transfer capability in the IAM. This information is used to determine if echo control is required on the call. The satellite indicator is filled with the satellite indicator in the IAM or CRM. It may be used to reject a call if too many satellites are used. The circuit status indicates if the given circuit is idle, blocked, or not blocked. The circuit state indicates the current state of the circuit, for example, active or transient. The time/date indicates when the idle circuit went idle.

FIG. **10** depicts an example of the trunk group table. During origination processing, the trunk group number from the trunk circuit table is used to key into the trunk table. Glare resolution indicates how a glare situation is to be resolved. Glare is dual seizure of the same circuit. If the glare resolution entry is set to "even/odd," the network element with the higher point code controls the even circuits, and the network element with the lower point code controls the odd circuits. If the glare resolution entry is set to "all," the CCM controls all of the circuits. If the glare resolution entry is set to "none," the CCM yields. The continuity control entry lists the percent of calls requiring continuity tests on the trunk group.

The common language location identifier (CLLI) entry is a Bellcore standardized entry. The satellite trunk group entry indicates that the trunk group uses a satellite. The satellite trunk group entry is used in conjunction with the satellite indicator field described above to determine if the call has used too many satellite connections and, therefore, must be rejected. The service indicator indicates if the incoming message is from a CCM (ATM) or a switch (TDM). The outgoing message index (OMI) points to the message table so that outgoing messages can obtain parameters. The associated number plan area (NPA) entry identifies the area code.

Selection sequence indicates the methodology that will be used to select a connection. The selection sequence field designations tell the trunk group to select circuits based on the following: least idle, most idle, ascending, descending, clockwise, and counterclockwise. The hop counter is decremented from the IAM. If the hop counter is zero, the call is released. Automatic congestion control (ACC) active indicates whether or not congestion control is active. If automatic congestion control is active, the CCM may release the call. During termination processing, the next function and index are used to enter the trunk circuit table.

FIG. **11** depicts an example of the exception table. The index is used as a pointer to enter the table. The carrier selection identification (ID) parameter indicates how the caller reached the network and is used for routing certain types of calls. The following are used for this field: spare or no indication, selected carrier identification code presubscribed and input by the calling party, selected carrier identification code presubscribed and not input by the calling party, selected carrier identification code presubscribed and no indication of input by the calling party, and selected carrier identification code not presubscribed and input by the calling party. The carrier identification (ID) indicates the network that the caller wants to use. This is used to route calls directly to the desired

network. The called party number nature of address differentiates between 0+ calls, 1+ calls, test calls, and international calls. For example, international calls might be routed to a pre-selected international carrier.

The called party "digits from" and "digits to" focus further processing unique to a defined range of called numbers. The "digits from" field is a decimal number ranging from 1-15 digits. It can be any length and, if filled with less than 15 digits, is filled with 0s for the remaining digits. The "digits to" field is a decimal number ranging from 1-15 digits. It can be any length and, if filled with less than 15 digits, is filled with 9s for the remaining digits. The next function and next index entries point to the next table which is typically the ANI table.

FIG. **12** depicts an example of the ANI table. The index is used to enter the fields of the table. The calling party category differentiates among types of calling parties, for example, test calls, emergency calls, and ordinary calls. The calling party\charge number entry nature of address indicates how the ANI is to be obtained. The following is the table fill that is used in this field: unknown, unique subscriber numbers, ANI not available or not provided, unique national number, ANI of the called party included, ANI of the called party not included, ANI of the called party includes national number, non-unique subscriber number, non-unique national number, non-unique international number, test line test code, and all other parameter values.

The "digits from" and "digits to" focus further processing unique to ANI within a given range. The data entry indicates if the ANI represents a data device that does not need echo control. Originating line information (OLI) differentiates among ordinary subscriber, multiparty line, ANI failure, station level rating, special operator handling, automatic identified outward dialing, coin or non-coin call using database access, 800/888 service call, coin, prison/inmate service, intercept (blank, trouble, and regular), operator handled call, outward wide area telecommunications service, telecommunications relay service (TRS), cellular services, private paystation, and access for private virtual network types of service. The next function and next index point to the next table which is typically the called number table.

FIG. **13** depicts an example of the called number table. The index is used to enter the table. The called number nature of address entry indicates the type of dialed number, for example, national versus international. The "digits from" and "digits to" entries focus further processing unique to a range of called numbers. The processing follows the processing logic of the "digits from" and "digits to" fields in FIG. **11**. The next function and next index point to the next table which is typically the routing table.

FIG. **14** depicts an example of the routing table. The index is used to enter the table. The transit network selection (TNS) network identification (ID) plan indicates the number of digits to use for the CIC. The transit network selection "digits from" and "digits to" fields define the range of numbers to identify an international carrier. The circuit code indicates the need for an operator on the call. The next function and next index entries in the routing table are used to identify a trunk group. The second and third next function/index entries define alternate routes. The third next function entry can also point back to another set of next functions in the routing table in order to expand the number of alternate route choices. The only other entries allowed are pointers to the treatment table. If the routing table points to the trunk group table, then the trunk group table typically points to a trunk circuit in the trunk circuit table. The yield from the trunk circuit table is the terminating connection for the call.

It can be seen from FIGS. **9-14** that the tables can be configured and relate to one another in such a way that call processes can enter the trunk circuit table for the originating connection and can traverse through the tables by keying on information and using pointers. The yield of the tables is typically a terminating connection identified by the trunk circuit table. In some cases, treatment is specified by the treatment table instead of a connection. If, at any point during the processing, a trunk group can be selected, processing may proceed directly to the trunk group table for terminating circuit selection. For example, it may be desirable to route calls from a particular ANI over a particular set of trunk groups. In this case, the ANI table would point directly to the trunk group table, and the trunk group table would point to the trunk circuit table for a terminating circuit. The default path through the tables is: trunk circuit, trunk group, exception, ANI, called number, routing, trunk group, and trunk circuit.

FIG. **15** depicts an example of the treatment table. Either the index or the message received cause number are filled and are used to enter the table. If the index is filled and used to enter the table, the general location, coding standard, and cause value indicator are used to generate an SS7 REL. The message received cause value entry is the cause value in a received SS7 message. If the message received cause value is filled and used to enter the table, then the cause value from that message is used in a REL from the CCM. The next function and next index point to the next table.

FIG. **16** depicts an example of the message table. This table allows the CCM to alter information in outgoing messages. Message type is used to enter the table, and it represents the outgoing standard SS7 message type. The parameter is the pertinent parameter within the outgoing SS7 message. The indexes point to various entries in the trunk group table and determine if parameters can be unchanged, omitted, or modified in the outgoing messages.

Operation of a detailed embodiment of the invention will now be discussed with reference to FIGS. **1-4**. Those skilled in the art will appreciate that numerous other examples could also be supported by the invention. An end user at residence **102** may request a telephone conversation with another end user at residence **116** by picking up telephone **210** and dialing the number of a telephone at residence **116**. As both end users are coupled to service nodes, this is an on-net call. Telephony card **332** in hub **304** of residence **102** will detect the off-hook, supply dial tone, and detect dialed digits. This information will be forwarded in a message carried over ATM cell(s) to session manager **442** at the service node **140** (**440** on FIG. **4**). Session manager **442** will determine that the call is on-net and send a control message to ATM switch **441** at service node **140** to establish an SVC from mux **120** to mux **126** through SONET rings **130** and **132** and ATM network **150**. (In the alternative, the session manager could contact each of these resources to set-up the connection.) The connections between the muxes and the residences have preferably been provisioned, but they may also be established on an SVC basis. Session manager **442** will instruct the telephony card at residence **116** to facilitate call set up, and the telephony card will ring the appropriate telephone. When the end user at residence **116** picks up the ringing telephone, a voice conversation may ensue over the end to end ATM path.

If an off-net call is attempted by an end-user at residence **102**, a similar process occurs except that session manager **442** at service node **140** recognizes the off-net destination and sends a control instruction to call manager **445** to process the call. In some embodiments, this could be a SS7 IAM, and in other embodiments it could be a control message provided over a non-SS7 interface. Call manager **445** processes the

dialed number and issues an SS7 Initial Address Message (IAM) to the appropriate network element in POTS network **160**. Session manager **442** instructs ATM switch **441** to set-up an SVC from mux **120** to AVM **444** at service node **140**. Call manager **445** instructs AVM **444** of the particular DS0 to interwork with this SVC. As a result, the call is extended from service node **140** to POTS network **160**. POTS network **160** completes the call in the conventional manner.

If an internet session is attempted by an end user at residence **102** using computer **214**, LAN card **330** in hub **204** at residence **102** will receive the connection request and forward it to Java card **320**. Java card **320** will send a control message to session manager **442** at service node **140**. Session manager **442** will instruct ATM switch **441** to establish an SVC from mux **120** to internet **170** through ATM network **150**. The connection between mux **120** and LAN card **330** may be established on an SVC basis, or it may already be provisioned. Because of the high bandwidth available, all three of the above communication sessions could occur simultaneously.

An important feature of the residential hub is the support of legacy applications by providing a proxy. An example is how the telephony card supports POTS calls. The telephones operate in their normal manner, and the telephony card provides an "interpreter" between the telephone and the session manager. This "interpreter" function is a proxy. A proxy could also be provided for legacy Internet communications. The LAN card or Java card could be programmed to act as the proxy. When a computer at the residence attempted an Internet communication, the proxy would intercept the IP packet. It could either translate the IP address into a destination and provides it to the session manager, or simply forward the IP address the session manager. Either way, the session manager would set up an ATM SVC to the destination. The legacy application on the computer could communicate using IP addressing, but would be supplied with ATM connections using the proxy.

The hub and session manager could provide proxy communications as follows. The session manager will house a generic service manager at an abstract level. The session manager will also house various service specific service managers derived from the generic service manager. Typically, the session manager houses the user agent and the residential hub houses the provider agent. The provider agent communicates with the service specific service manager to negotiate a service request. In a proxy situation, the proxy at the hub becomes the provider agent in the TINA model. This proxy/provider agent at the hub will communicate with the service specific service manager at the session manager to set-up the communications session.

In addition to establishing connections, the residential hub and service node provide a powerful platform to deliver services to the end user. The feature server at the service node could download Java applets to the Java CPU at the residential hub. This opens up a vast array of Java based services and could facilitate the use of network computers at the residence. These Java applets could be used to provide class 5 features to the telephones at the residence. For example, if the user requests call forwarding, a call forwarding Java applet could be downloaded to the Java card. The Java card could interface with the user (i.e. over a telephone or computer) to collect the forwarding number. The Java card could then provide the forwarding number to the session manager. The session manager would direct all subsequent calls to the forwarding number. The feature server could also house a call-waiting applet. If a user invokes call-waiting, the feature server would download a call-waiting applet to the Java card. The Java card would control the telephony card to notify the user when an incoming call arrives during off-hook. The end-user would indicate acceptance of the other call with a hook flash detected by the telephony card. The end user class 5 features that today are provided centrally by a class 5 switch can be distributed over the residential communications hub, the session manager, and the feature server in this system. Allocation of intelligence in this manner offers the flexibility to easily customize and compose new services in a modular way. The following examples explain how some common class 5 features can be distributed. The provider agent in the residential hub can be responsible for performing the caller ID and call waiting features. Depending on the capabilities of the phones connected to the residential communications hub, the provider agent can notify the user either visually or with audio messages. This is handled independently without the involvement of the session manaager. On the other hand, call forwarding is responsible for capturing the forwarding number from the user. This information is passed to the session manager which updates call routing tables accordingly. In addition to serving as a repository for class 5 feature related applets that may be downloaded to a residential communications hub, the feature server will have shared resources such as audio bridges to provide conference calling features to the end users. Those skilled in the art will appreciate how numerous features could be supplied in this manner.

The feature server could also store personalized customer profiles and features. For example, personal intranets and browsers for end users could be stored in the feature server. By clicking an icon on a computer screen, an end user could access a personalized browser downloaded from the feature server. The personalized browser could be used to establish numerous forms of communications. One click on the browser could result in a telephone call set-up by the session manager—either on-net or off-net. Another click on the browser could result in the retrieval of information from the World Wide Web using a Uniform Resource Locator (URL).

The feature server could also house personalized web pages for end users. The end users could monitor and modify their web page from their home computer. Others would be able to access the web page in the conventional way by accessing the feature server from the Internet. This would allow the end user to utilize e-mail through their web page. The feature server could be used to house media resources for the end users. A few examples would be yellow pages of Internet directories. The feature server could also provide a voice mail platform for the end user. The feature server could download various forms of software to the computers at the residence—for example, banking software.

As demonstrated above, the invention provides a powerful platform for delivering services to the end user. By providing POTS service using the telephony card, Java card, feature server, and session manager, POTS traffic can be integrated with other residential traffic over an ATM system. This allows the network to combine all traffic onto an ATM core. This also allows the network to offer a complete communications package to the end-user. In addition to POTS, the service node can provide other capabilities, such as home security, telecommuting, Internet connections, electronic gaming, electronic commerce, and video applications.

We claim:

1. A communication system to provide Public Switched Telephone Network (PSTN) access to a residential communication hub, the communication system comprising:

the residential communication hub coupled to a packet network over a packet connection configured to exchange telephony control signaling and telephony

user communications in a PSTN format with an analog telephone, convert the telephony control signaling and the telephony user communications in the PSTN format to a packet format, exchange the telephony control signaling in the packet format with a service node over the packet connection, wherein the service node comprises a call manager and a voice mux, exchange the telephony user communications in the packet format with the service node over the packet connection, and exchange Internet communications with the service node over the packet connection;

wherein the call manager is coupled to the packet network and configured to process the telephony control signaling to select a PSTN connection of the PSTN, transfer a control message indicating the selected PSTN connection, convert the telephony control signaling between the packet format and the PSTN format, and exchange the telephony control signaling in the PSTN format with the PSTN over a signaling interface of the PSTN; and

wherein the voice mux is coupled to the packet network and configured to receive the control message from the call manager, and in response, to exchange the telephony user communications in the packet format with the residential communication hub, convert the telephony user communications between the packet format and the PSTN format, and exchange the telephony user communications in the PSTN format over the selected PSTN connection.

2. The communications system of claim **1** wherein the packet format comprises asynchronous transfer mode.

3. The communications system of claim **1** wherein the packet connection comprises a Digital Subscriber Line (DSL) connection.

4. The communications system of claim **1** wherein the packet connection comprises a wireless connection.

5. The communications system of claim **1** wherein the residential communication hub is configured to receive video communications in the packet format over the packet connection.

6. The communications system of claim **1** wherein the residential communication hub is configured to provide echo cancellation for the telephony user communications.

7. The communications system of claim **1** wherein the voice mux is configured to provide echo cancellation for the telephony user communications.

8. The communications system of claim **1** wherein the service node further comprises a session manager; and wherein the session manager is coupled to the packet network and configured to exchange user information in the packet format with the residential communication hub; and wherein the session manager is configured to store and implement call management rules for the residential communication hub in response to the user information provided through an HTML browser.

9. The communications system of claim **1** wherein the telephony control signaling in the PSTN format comprises an initial address message.

10. The communications system of claim **1** wherein the selected PSTN connection comprises a DS0 connection.

11. A method of operating a communication system to provide Public Switched Telephone Network (PSTN) access to a residential communication hub, the method comprising:

in the residential communication hub that is coupled to a packet network over a packet connection, exchanging telephony control signaling and telephony user communications in a PSTN format with an analog telephone, converting the telephony control signaling and the telephony user communications in the PSTN format to a packet format, exchanging the telephony control signaling in the packet format with a service node over the packet connection, wherein the service node comprises a call manager and a voice mux, exchanging the telephony user communications in the packet format with the service node over the packet connection, and exchanging Internet communications with the service node over the packet connection;

in the call manager that is coupled to the packet network, processing the telephony control signaling to select a PSTN connection of the PSTN, transferring a control message indicating the selected PSTN connection, converting the telephony control signaling between the packet format and the PSTN format, and exchanging the telephony control signaling in the PSTN format with the PSTN over a signaling interface of the PSTN; and

in the voice mux that is coupled to the packet network, receiving the control message from the call manager, and in response, exchanging the telephony user communications in the packet format with the residential communication hub, converting the telephony user communications between the packet format and the PSTN format, and exchanging the telephony user communications in the PSTN format over the selected PSTN connection.

12. The method of claim **11** wherein the packet format comprises asynchronous transfer mode.

13. The method of claim **11** wherein the packet connection comprises a Digital Subscriber Line (DSL) connection.

14. The method of claim **11** wherein the packet connection comprises a wireless connection.

15. The method of claim **11**, further comprising in the residential communication hub, receiving video communications in the packet format over the packet connection.

16. The method of claim **11**, further comprising in the residential communication hub, providing echo cancellation for the telephony user communications.

17. The method of claim **11**, further comprising in the voice mux, providing echo cancellation for the telephony user communications.

18. The method of claim **11**, further comprising in a session manager of the service node that is coupled to the packet network, exchanging user information in the packet format with the residential communication hub, and in the session manager, storing and implementing call management rules for the residential communication hub in response to the user information provided through an HTML browser.

19. The method of claim **11** wherein the telephony control signaling in the PSTN format comprises an initial address message.

20. The method of claim **11** wherein the selected PSTN connection comprises a DS0 connection.

* * * * *

EXHIBIT N

US006563918B1

(12) United States Patent
Nelson et al.

(10) Patent No.: US 6,563,918 B1
(45) Date of Patent: May 13, 2003

(54) **TELECOMMUNICATIONS SYSTEM ARCHITECTURE FOR CONNECTING A CALL**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/026,906**

(22) Filed: **Feb. 20, 1998**

(51) **Int. Cl.**[7] **H04M 7/00**; H04L 12/28

(52) **U.S. Cl.** **379/230**; 379/221.08; 370/385; 370/395.2; 370/397; 370/409; 370/465; 370/522

(58) **Field of Search** 379/207.02, 221.08, 379/221.09, 221.13, 229, 230; 370/259, 385, 395.2, 396, 397, 400, 401, 402, 409, 426, 465, 466, 467, 468, 522, 524

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,201,889	A	5/1980	Lawrence et al.
4,310,727	A	1/1982	Lawser
4,348,554	A	9/1982	Asmuth
4,453,247	A	6/1984	Suzuki et al.
4,554,659	A	11/1985	Blood et al.
4,565,903	A	1/1986	Riley
4,683,563	A	7/1987	Rouse et al.

(List continued on next page.)

FOREIGN PATENT DOCUMENTS

EP	90312739.7	7/1991
EP	91303312.2	10/1991
EP	91311342.9	7/1992
EP	92307752.3	9/1993
JP	870284896	5/1989
JP	07050057	9/1996
WO	WO94/06251	3/1994
WO	WO95/04436	2/1995

OTHER PUBLICATIONS

Tanabe, Shirou, Taihei, Suzuki, and Ohtsuki, Ken–Ichi, "A New Distributed Switching System Architecture for B–ISDN," International Conference on Integrated Broadband Services and Networks, Oct. 15–18, 1990, The Institution of Electrical Engineers, Savoy Place, London.

Palmer, Rob, "An Experimental ATM Network for B–ISDN Research," IEEE 1992, Melbourne, Australia.

Thomas F. Laporta, "Distributed Call Processing for Wireless Mobile Networks," Bell Labs Technical Journal, vol. 1 (No. 1), pp. 127–142, (Oct., 1996).

(List continued on next page.)

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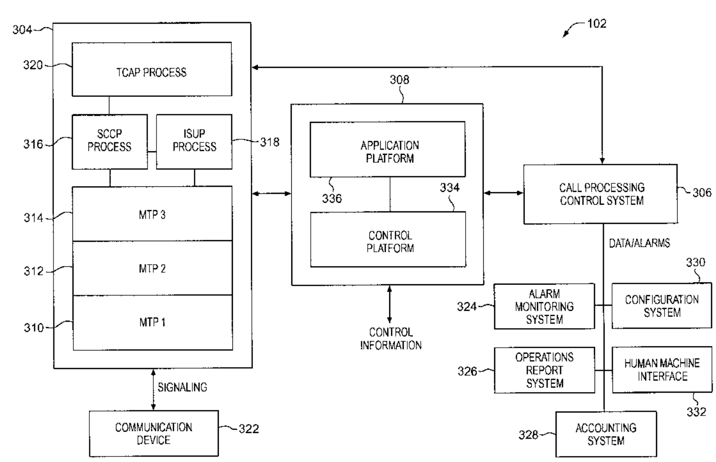
(57) ABSTRACT

An architecture for connecting a call comprises a call processor, a signaling interface, a call process control system (CPCS), and an interworking unit. The signaling interface receives, transmits, and processes call signaling so that call signaling is received into, or transported from, the architecture through the signaling interface. The call processor processes the call signaling to select connections for calls. The CPCS receives data fills from translations, processes the data to be in a format compatible with the call processor, and fills the data into tables in the call processor. The CPCS also interfaces through the signaling processor with other systems, such as accounting systems and operations centers. The interworking unit interworks user communications between time division multiplex and asynchronous transfer mode connections and between time division multiplex connections and other time division multiplex connections.

20 Claims, 9 Drawing Sheets



U.S. PATENT DOCUMENTS

4,720,850 A 1/1988 Oberlander
4,730,312 A 3/1988 Johnson
4,736,364 A 4/1988 Basso et al.
4,748,658 A 5/1988 Gopal
4,763,317 A 8/1988 Lehman
4,823,338 A 4/1989 Chan et al.
4,853,955 A 8/1989 Thorn et al.
4,896,319 A 1/1990 Lidinsky et al.
4,916,690 A 4/1990 Barri
4,926,416 A 5/1990 Weik
4,979,118 A 12/1990 Kheradpir
4,985,889 A 1/1991 Frankish et al.
4,991,204 A 2/1991 Yamamoto et al.
4,993,104 A 2/1991 Gordon
5,003,584 A 3/1991 Benyacar
5,018,191 A 5/1991 Catron et al.
5,048,081 A 9/1991 Gavaras
5,058,104 A 10/1991 Yonehara et al.
5,067,123 A 11/1991 Hyodo et al.
5,084,867 A 1/1992 Tachibana et al.
5,089,954 A 2/1992 Rago
5,091,903 A 2/1992 Schrodi
5,101,404 A 3/1992 Kunimoto et al.
5,115,431 A 5/1992 Williams et al.
5,163,057 A 11/1992 Grupp
5,168,492 A 12/1992 Beshai et al.
5,185,743 A 2/1993 Murayama
5,193,110 A 3/1993 Jones et al.
5,204,857 A 4/1993 Obara
5,216,669 A 6/1993 Hofstetter et al.
5,218,602 A 6/1993 Grant et al.
5,231,631 A 7/1993 Buhrke et al.
5,231,633 A 7/1993 Hluchyi et al.
5,233,607 A 8/1993 Barwig et al.
5,239,539 A 8/1993 Uchida et al.
5,249,178 A 9/1993 Kurano et al.
5,251,255 A 10/1993 Epley
5,253,247 A 10/1993 Hirose et al.
5,255,266 A 10/1993 Watanabe et al.
5,258,752 A 11/1993 Fukaya et al.
5,258,979 A 11/1993 Oomuro et al.
5,268,895 A 12/1993 Topper
5,271,010 A 12/1993 Miyake
5,274,680 A 12/1993 Sorton et al.
5,278,889 A 1/1994 Papanicolaou et al.
5,282,244 A 1/1994 Fuller et al.
5,285,441 A 2/1994 Bansal et al.
5,291,479 A 3/1994 Vaziri et al.
5,306,318 A 4/1994 Bachhuber et al.
5,311,509 A 5/1994 Heddes et al.
5,317,562 A 5/1994 Nardin et al.
5,323,389 A 6/1994 Bitz et al.
5,327,421 A 7/1994 Hiller et al.
5,327,433 A 7/1994 Hall
5,329,308 A 7/1994 Binns et al.
5,339,318 A 8/1994 Tanaka
5,345,443 A 9/1994 D'Ambrogio et al.
5,345,445 A 9/1994 Hiller
5,345,446 A 9/1994 Hiller
5,357,510 A 10/1994 Norizuki et al.
5,363,433 A 11/1994 Isono
5,365,524 A 11/1994 Hiller et al.
5,367,566 A 11/1994 Moe et al.
5,373,504 A 12/1994 Tanaka et al.
5,375,124 A 12/1994 D'Ambrogio
5,377,186 A 12/1994 Wegner
5,384,771 A 1/1995 Isidoro et al.
5,384,840 A 1/1995 Blatchford et al.
5,392,402 A 2/1995 Robrock
5,394,393 A 2/1995 Brisson et al.
5,394,398 A 2/1995 Rau
5,414,701 A 5/1995 Shtayer et al.
5,418,783 A 5/1995 Yamaki et al.
5,420,857 A 5/1995 Jurkevich
5,420,858 A 5/1995 Marshall et al.
5,420,916 A 5/1995 Sekiguchi
5,422,882 A 6/1995 Hiller
5,425,090 A 6/1995 Orriss
5,426,636 A 6/1995 Hiller et al.
5,428,607 A 6/1995 Hiller et al.
5,428,609 A 6/1995 Eng et al.
5,434,852 A 7/1995 LaPorta
5,434,981 A 7/1995 Lenihan et al.
5,440,563 A 8/1995 Isidoro et al.
5,444,713 A 8/1995 Backaus et al.
5,446,738 A 8/1995 Kim et al.
5,452,297 A 9/1995 Hiller et al.
5,453,981 A 9/1995 Katsube et al.
5,454,034 A 9/1995 Martin
5,457,684 A 10/1995 Bharucha
5,461,669 A 10/1995 Vilain
5,463,620 A 10/1995 Sriram
5,463,621 A 10/1995 Suzuki
5,473,677 A 12/1995 D'Amato
5,473,679 A 12/1995 LaPorta
5,477,537 A 12/1995 Dankert et al.
5,479,401 A 12/1995 Bitz et al.
5,479,402 A 12/1995 Hata et al.
5,479,495 A 12/1995 Blumhardt
5,483,527 A 1/1996 Doshi et al.
5,485,455 A 1/1996 Dobbins et al.
5,495,484 A 2/1996 Self et al.
5,504,742 A 4/1996 Kakuma et al.
5,506,844 A 4/1996 Rao
5,509,010 A 4/1996 LaPorta
5,509,123 A 4/1996 Dobbins et al.
5,513,178 A 4/1996 Tanaka
5,513,355 A 4/1996 Doellinger et al.
5,519,707 A 5/1996 Subramanian et al.
5,521,910 A 5/1996 Matthews
5,522,042 A 5/1996 Fee et al.
5,526,414 A 6/1996 Bedard et al.
5,533,106 A 7/1996 Blumhardt
5,539,698 A 7/1996 Kozaki et al.
5,539,815 A 7/1996 Samba
5,539,816 A 7/1996 Pinard et al.
5,539,884 A 7/1996 Robrock
5,541,918 A 7/1996 Ganmukhi et al.
5,541,926 A 7/1996 Saito et al.
5,544,152 A 8/1996 Obermanns et al.
5,544,161 A 8/1996 Bigham et al.
5,546,398 A 8/1996 Tucker et al.
5,548,580 A 8/1996 Buckland
5,550,819 A 8/1996 Duault
5,550,820 A 8/1996 Baran
5,550,914 A 8/1996 Clarke et al.
5,563,939 A 10/1996 La Porta et al.
5,566,173 A 10/1996 Steinbrecher
5,568,475 A 10/1996 Doshi
5,570,368 A 10/1996 Murakami et al.
5,572,583 A 11/1996 Wheeler, Jr. et al.
5,577,039 A 11/1996 Won et al.
5,579,311 A 11/1996 Chopping et al.
5,587,999 A 12/1996 Endo
5,592,477 A 1/1997 Farris et al.
5,600,640 A 2/1997 Blair et al.
5,600,643 A 2/1997 Robrock
5,623,491 A 4/1997 Skoog
5,627,836 A 5/1997 Conoscenti et al.
5,629,930 A 5/1997 Beshai et al.
5,635,980 A 6/1997 Lin et al.

5,636,210 A		6/1997	Agrawal et al.	
5,640,446 A		6/1997	Everett et al.	
5,661,725 A		8/1997	Buck	
5,666,349 A		9/1997	Petri	
5,673,262 A		9/1997	Shimizu	
5,680,390 A		10/1997	Robrock	
5,703,876 A		12/1997	Christie	
5,708,702 A		1/1998	DePaul et al.	
5,710,769 A		1/1998	Anderson et al.	
5,719,863 A		2/1998	Hummel	
5,751,706 A		5/1998	Land	
5,825,780 A		10/1998	Christie	
5,835,584 A		11/1998	Penttonen	
5,844,895 A		12/1998	Gradisching	
5,848,128 A		12/1998	Frey	
5,867,562 A		2/1999	Scherer	
5,920,562 A		7/1999	Christie et al.	
5,926,482 A		7/1999	Christie	
5,940,393 A	*	8/1999	Duree et al.	370/392
5,940,487 A		8/1999	Bunch et al.	
5,940,491 A		8/1999	Anderson et al.	
5,991,301 A		11/1999	Christie	
6,002,689 A		12/1999	Christie et al.	
6,005,845 A		12/1999	Svennesson et al.	
6,016,343 A		1/2000	Hogan et al.	
6,023,474 A		2/2000	Gardner	
6,031,840 A		2/2000	Christie	
6,061,364 A		5/2000	Hager et al.	
6,081,529 A		6/2000	Christie	
6,137,800 A	*	10/2000	Wiley et al.	370/258
6,181,703 B1		1/2001	Christie et al.	
6,314,103 B1	*	11/2001	Medhat et al.	370/395.2

OTHER PUBLICATIONS

Beckman, Richard T. and Matthews, Joseph R., "Proposal for a Physical Architecture Based on the Harmonized Functional Architecture," Committee T1 Contribution T1S1.5/95–027, Bellcore, (Feb. 20, 1995).

Yoshikai, N., et al., "Report of the Meeting of SWP 13/1–4 (Draft Recommendation I.580)," ITU–T Telecommunication Standardization Sector, Study Group 13, pp. 1–51, (Mar. 7–18, 1994).

N/A, "Final Draft Text for Broadband Capability Set 2 Signaling Requirements, Attachment "D" Special Drafting Meeting," ITU–T Telecommunications Standardization Sector, Study Group 11, p. 1–127, (Sep. 13–22, 1993).

Ohta, S., et al., "A Dynamically Controllable ATM Transport Network Based on the Virtual Path Concept," Communications for the Information Age, Globecom'88, Conference Record, p. 1272–1276, (Nov. 28–Dec. 1, 1988).

Fukazawa, M., et al., "Intelligent Network Call Model for Broadband ISDN," Fujitsu Laboratories, Ltd. (Japan), p. 30.6.1–30.6.5.

Minzer, Steven, "A Signaling Protocol for Complex Multimedia Services," IEEE Journal on Selected Areas in Communications (ISSN 0733–8716), vol. 9 (No. 9), p. 1383–1394, (Dec. 1991).

Faynberg, I., et al., "The Support of Network Interworking and Distributed Context Switching in the IN Service Data Function Model," 2nd Colloque International, ICIN 92, p. 11–16, (Mar. 1992).

Woodworth, Clark B., et al., "A Flexible Broadband Packet Switch for a Multimedia Integrated Network," International Conference on Communications, Denver, ICC–91, p. 3.2.1–3.2.8, (Jun. 1991).

Miller, P., "Intelligent Network/2: A flexible framework for exchange services," Bell Communications Research EXCHANGE, vol. 3 (No. 3), (May/Jun. 1987).

Cooper, C., et al., "Toward a Broadband Congestion Control Strategy," IEEE Network, The Magazine of Computer Communications, (May 1990).

Batten, A., "A Personal Communications Services and the Intelligent Network," British Telecommunications Engineering, (Aug. 1990).

Fujioka, M., et al., "Universal Service Creation and Provision Environment for Intelligent Network," IEEE Communications Magazine, (Jan. 1991).

Andrews, F., "Switching in a Competitive Market," IEEE Communications Magazine, (Jan. 1991).

N/A, "Network Signaling," Telephony, TCX12004, University of Excellence, p. 5.8–5.17, (Oct. 21, 1991).

Garrahan, J.J., et al., "Intelligent Network Overview," IEEE Communications Magazine, p. 30–36, (Mar. 1993).

Johnson, M.A., et al., "New Service Testing Functions for Advanced Intelligent Networks," IEEE 1992 Network Operations and Management Symposium, p. 709–720, (Apr. 6, 1992).

Yeh, S.Y., et al., "The Evolving Intelligent Network Architecture," IEEE Conference on Computer and Communication Systems, p. 835–839, (1990).

Atoui, M., "Virtual Private Network Call Processing in the Intelligent Network," International Conference on Communications, p. 561–565, (1992).

Bosco, P., et al., "A Laboratory for AIN Service Design and Validation," International Conference on Communications, p. 566–571, (Jun. 14, 1992).

Homa, J., et al., "Intelligent Network Requirements for Personal Communications Services," IEEE Communications Magazine, p. 70–76, (Feb. 1992).

Russo, E.G., et al., "Intelligent Network Platforms in the U.S.," AT&T Technical Journal, p. 26–43, (1991).

Van Den Broek, W., et al., "RACE 2066–Functional models of UMTS and integration into the future networks," Electronics & Communications Engineering Journal, p. 165–172, (Jun. 1993).

Pinkham, G., et al., "The Ericsson Approach to Intelligent Networks," IEEE Global Telecommunications Conference & Exhibition, Session 10, paragraph 4, p. 320–324, (1988).

N/A, "ANSI–TI.111–1992, Signaling System No. 7 (SS7)—Message Transfer Part (MTP)," American National Standard for Telecommunications.

N/A, "ANSI–TI.112–1992, Signaling System No. 7 (SS7)—Signaling Connection Control Part (SCCP)," American National Standard for Telecommunications.

N/A, "ANSI–TI.113–1992, Signaling System No. 7 (SS7)—Integrated Services digital Network (ISDN) User Part," American National Standard for Telecommunications.

N/A, "ANSI–TI.113a–1993, Signaling System No. 7 (SS7)—Integrated Services Digital Network (ISDN) User Part (NxDSO Multi–rate Connection)," American National Standard for Telecommunications.

N/A, "ANSI–TI.113–1995, Signaling System No. 7 (SS7)—Integrated Services Digital Network (ISDN) User Part," American National Standard for Telecommunications.

N/A, "ATM at a Glance," Transmission Technologies Access Guide, p. 40–42, (1993).

Paglialunga, A., "ISCP Baseline Document (VER 3.1)," ITU Telecommunication Standardization Sector, Centre Studi E Laboratori Telecommunicazioni S.p.A., (1993).

N/A, "A Technical Report on SPEECH PACKETIZATION," Document T1A1/94—Prepared by T1A1.7, Working Group on Specialized Signal Processing.
N/A, "Draft Revised Recommendation I.580," ITU—Telecommunication Standardization Sector, Study Group 13, (Jul. 10–21, 1995).
Sprague, David, "MTP Level–3 Gateway STP Release 3.2.0," TEKELEC, p. 1–48, (Aug. 4, 1995).
McDysan, David E. and Spohn, Darren L., "ATM Theory and Application," ATM Layer VPI/VCI Level Addressing, p. 256: 9.3.1, (1994).
Minoli, Daniel and Dobrowski, George, "Principles of Signaling for Cell Relay and Frame Relay," DVI Comm., Inc. / Stevens Institute of Technology / Bell Comm. Research (Bellcore), p. 1–2, 5–6 and 229, (1994).
N/A, "B–IDSN ATM Adaptation Layer (AAL) Specification, Types 1 & 2," ITU Draft Recommendation I.363.1, (Jul. 21, 1995).
N/A, "Circuit Emulation Service Interoperability Specification Version 2.0 (Baseline Draft), 95–1504," The ATM Forum Technical Committee, (Dec. 1995).
N/A, "IN/B–ISDN Signalling Three Ways of Integration," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29–Dec. 17, 1993).
N/A, "Interworking B–ISUP and Q.93B for DDI, MSN, TP and SUB," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29–Dec. 17, 1993).
N/A, "Revised Draft of Q.2650 (DSS2/B–ISUP Interworking Recommendation)," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29–Dec. 17, 1993).
N/A, "Draft Broadband / Narrowband NNI interworking recommendation," ITU—Telecommunication Standardization Sector, Study Group 11, (Dec. 1993).
N/A, "Draft Recommendation Q.2761," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29–Dec. 17, 1993).
N/A, "Draft Recommendation Q.2762," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29–Dec. 17, 1993).
N/A, "Q.2931 Overview," ITU—Telecommunication Standardization Sector, (Nov. 29–Dec. 17, 1993).
N/A, "Clean final draft text for B–ISUP formats and codes (Q.2763) in ASN.1," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29–Dec. 17, 1993).
N/A, "Updated draft of Q.2764 (BQ.764)," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29–Dec. 17, 1993).
N/A, "Final B–ISUP SDLs," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29–Dec. 17, 1993).
N/A, "Draft Recommendation Q.2650," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29–Dec. 17, 1993).
N/A, "Revised Draft of Q.2650 (DSS2/B–ISUP Interworking Recommendation)," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29–Dec. 17, 1993).
N/A, "Revision of Recommendation of Q.850," ITU—T SG 11 WP 2, (Dec. 2–15, 1993).
N/A, "Draft Text for Q.2931 (CH. 1, 2 and 3)," ITU—Telecommunication Standardization Sector, Study Group 11, (Dec. 1993).
N/A, "Q.2931, Clause 4—Information Elements," ITU—Telecommunication Standardization Sector, (Nov. 29–Dec. 17, 1993).
N/A, "Section 5 of Q.93B," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29–Dec. 17, 1993).
N/A, "Chapter 6 of Recommendation Q.93B," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29–Dec. 17, 1993).
N/A, "Clauses 7 and 8 of Q.2931," ITU—Telecommunication Standardization Sector, Study Group 11, (Dec. 1993).
N/A, "Revised Q.2931 User Side SDL Diagrams," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29–Dec. 17, 1993).
N/A, "Revised Q.2931 Network Side SDL Diagrams," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29–Dec. 17, 1993).
N/A, "AnnexesB, C, D, F, H and I of Q.2931," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29–Dec. 17, 1993).
N/A, "Annex E of Recommendation Q.93B," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29–Dec. 17, 1993).
N/A, "Rec. Q.2931, Annex G—Status Monitoring of SPCs," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29–Dec. 17, 1993).
N/A, "Annex J of Q.2931," ITU—Telecommunication Standardization Sector, Study Group 11, (Dec. 1993).
N/A, "Appendix 1/Q.2931: Guidelines for the Use of Instruction Indicators," ITU—Telecommunication Standardization Sector, Study Group 11, (Nov. 29–Dec. 17, 1993).
N/A, "Draft text for Q.2931: Appendix II (Information Items Required for Connection Establishment and Routing in B–ISDN)," ITU—Telecommunication Standardization Sector, Study Group 11.
N/A, "General Recommendations on Telephone Switching and Signalling—Intelligent Network / Distributed Functional Plane for Intelligent Network CS–1," ITU–T Recommendation Q.1214.
Kumar, Sanjay, "Legacy Voice Service at a Native ATM Terminal," ATM_Forum/95–0917R1, ATM Forum Technical Committee, (Oct. 2–6, 1995).
Duault, Maurice, et al., "Baseline Text for Voice and Telephony Over ATM—ATM Trunking for Narrowband Services," ATM_Forum/95–0446R3, ATM Forum Technical Committee, (Oct. 2–6, 1995).
Choi, Don, "Requirements for ATM Trunking," ATM_Forum/95–1401, ATM Forum Technical Committee, (Oct. 2–6, 1995).
Chiang, Chin, "Proposed Changes to Proxy Signaling Capability," ATM Forum/95–0046, ATM Forum: Signaling Working Group, (Feb. 6–10, 1995).
Amin–Salehi, Bahman, "Third Party Call Setup for a Video–on Demand Connection Establishment," ATM_Forum/95–0022, ATM Forum Technical Committee, (Feb. 5–8, 1995).
Caves, Keith, "Proposed Modifications to the Baseline Text (95–0446R2) of the 'VTOA—ATM Trunking for Narrowband Services' Specification," ATM Forum/95–1134, ATM Forum Technical Committee, (Oct. 2–6, 1995).

Schink, Helmut, et al., "CES as a Flexible Trunking Method," ATM_Forum/95–1157, ATM Forum Technical Committee, (Oct. 2–6, 1995).
Duault, Maurice, "Proposal for ATM Trunking Options," ATM_Forum/95–1230, ATM Forum Technical Committee, (Oct. 2–6, 1995).
Okutani, Takenori, et al., "VTOA: Reference Configuration–ATM Trunking for Narrowband Services," ATM–Forum/95–1364, ATM Forum Technical Committee, (Oct. 2–6, 1995).
Stodola, Kevin, "Circuit Emulation Services Version 2 Baseline," ATM_Forum/95–1504, ATM Forum Technical Committee, (Dec. 11–15, 1995).
N/A, "I.751 Asynchronous Transfer Mode (ATM) Management View of the Network Element View," ITU—Telecommunication Standardization Sector, Study Group 15, (Nov. 13–24, 1995).
N/A, "Draft I.732," ITU—Telecommunication Standardization Sector, Study Group 15, (Nov. 13–24, 1995).
N/A, "Editorial Modifications for Draft New ITU–T Recommendation I.731," ITU—Telecommunication Standardiztion Sector, Study Group 15, (Nov. 13–24, 1995).
Buhrke, R.E., "Proposed Unified Functional Model," T1S1.5/95–036, Committee T1 Contribution, (Feb. 1995).

* cited by examiner

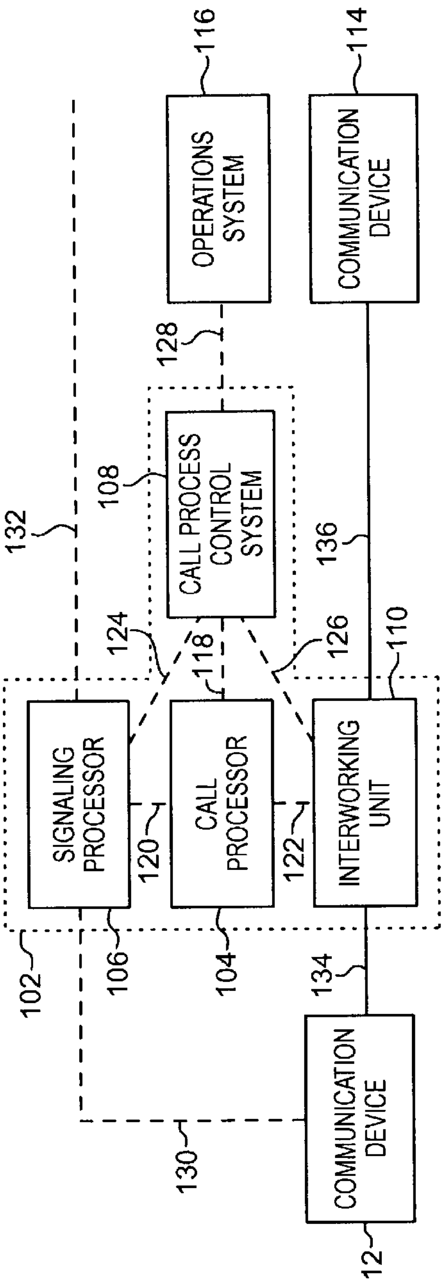

OPERATIONS SYSTEM
COMMUNICATION DEVICE
CALL PROCESS CONTROL SYSTEM
SIGNALING PROCESSOR
CALL PROCESSOR
INTERWORKING UNIT
COMMUNICATION DEVICE
102
104
106
108
110
112
114
116
118
120
122
124
126
128
130
132
134
136

FIG. 1

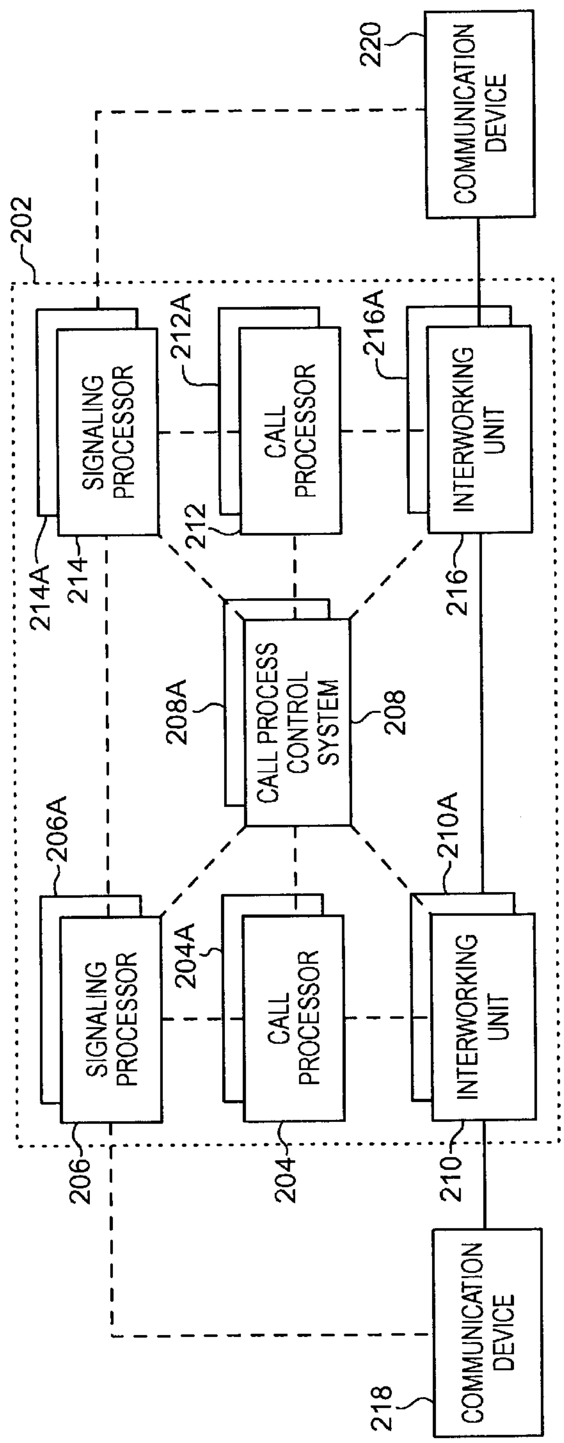

COMMUNICATION DEVICE
SIGNALING PROCESSOR
CALL PROCESSOR
INTERWORKING UNIT
CALL PROCESS CONTROL SYSTEM
SIGNALING PROCESSOR
CALL PROCESSOR
INTERWORKING UNIT
COMMUNICATION DEVICE
202
204
204A
206
206A
208
208A
210
210A
212
212A
214
214A
216
216A
218
220

FIG. 2

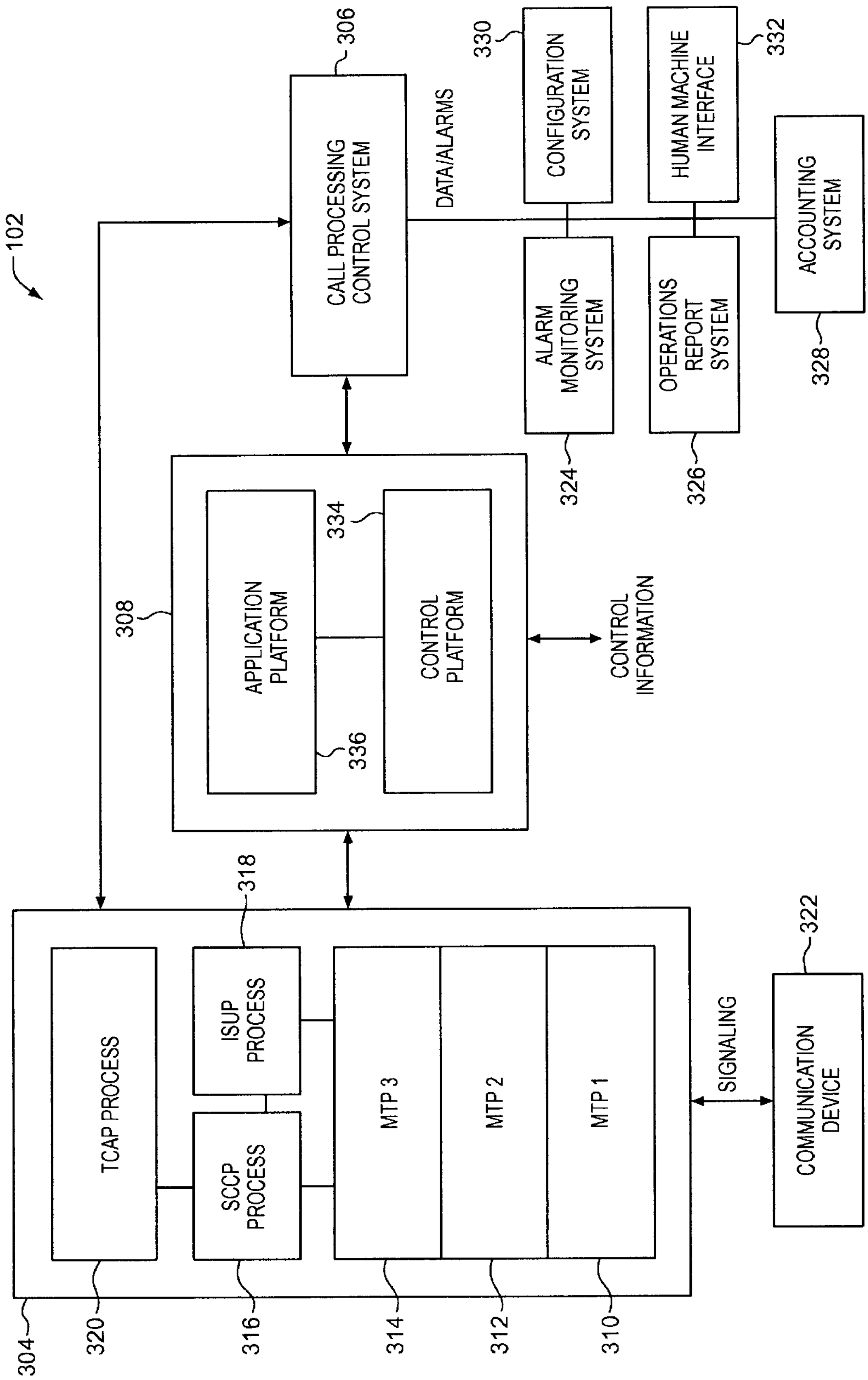

102
CALL PROCESSING CONTROL SYSTEM
306
DATA/ALARMS
CONFIGURATION SYSTEM
330
HUMAN MACHINE INTERFACE
332
ACCOUNTING SYSTEM
328
ALARM MONITORING SYSTEM
324
OPERATIONS REPORT SYSTEM
326
308
APPLICATION PLATFORM
336
334
CONTROL PLATFORM
CONTROL INFORMATION
318
TCAP PROCESS
ISUP PROCESS
SCCP PROCESS
MTP 3
MTP 2
MTP 1
SIGNALING
COMMUNICATION DEVICE
322
304
320
316
314
312
310

FIG. 3

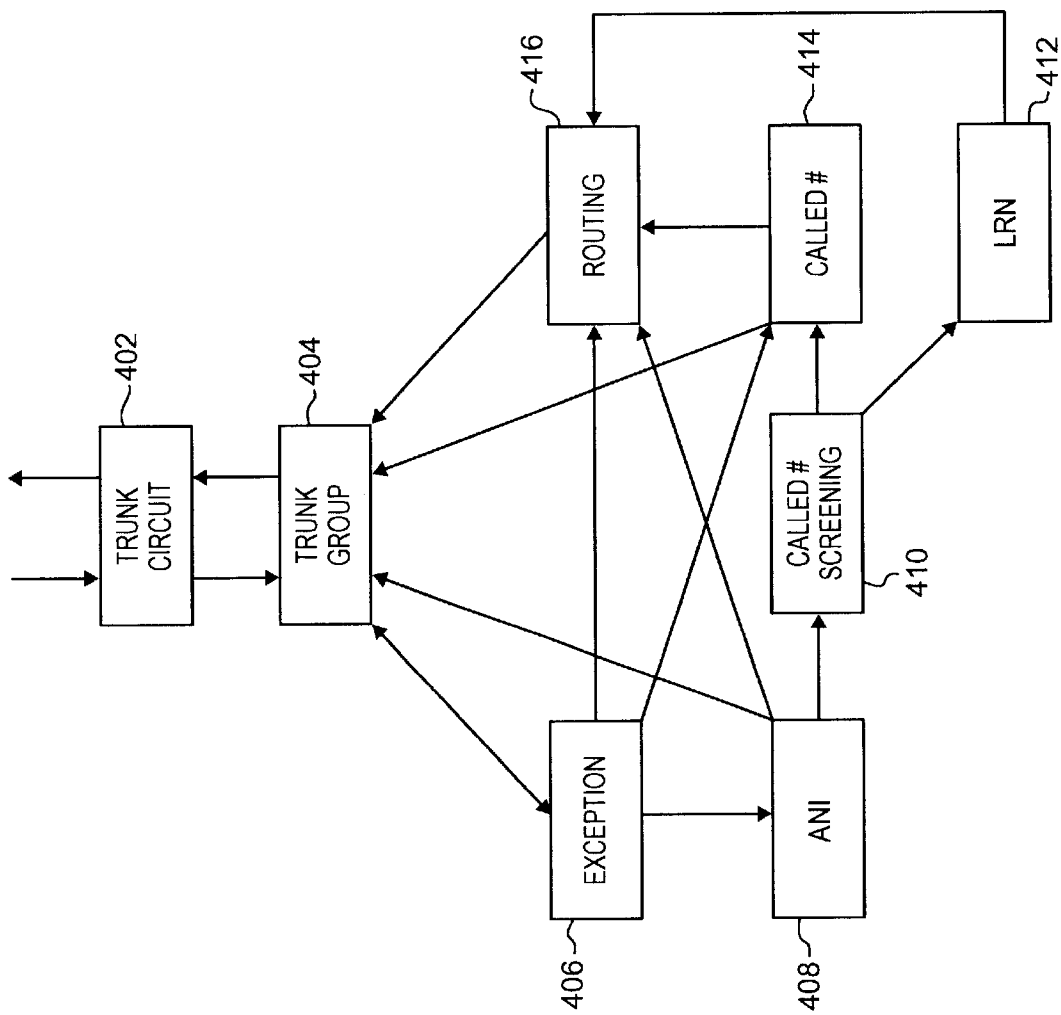

TRUNK CIRCUIT
402
TRUNK GROUP
404
ROUTING
416
CALLED #
414
LRN
412
CALLED # SCREENING
410
EXCEPTION
406
ANI
408

FIG. 4

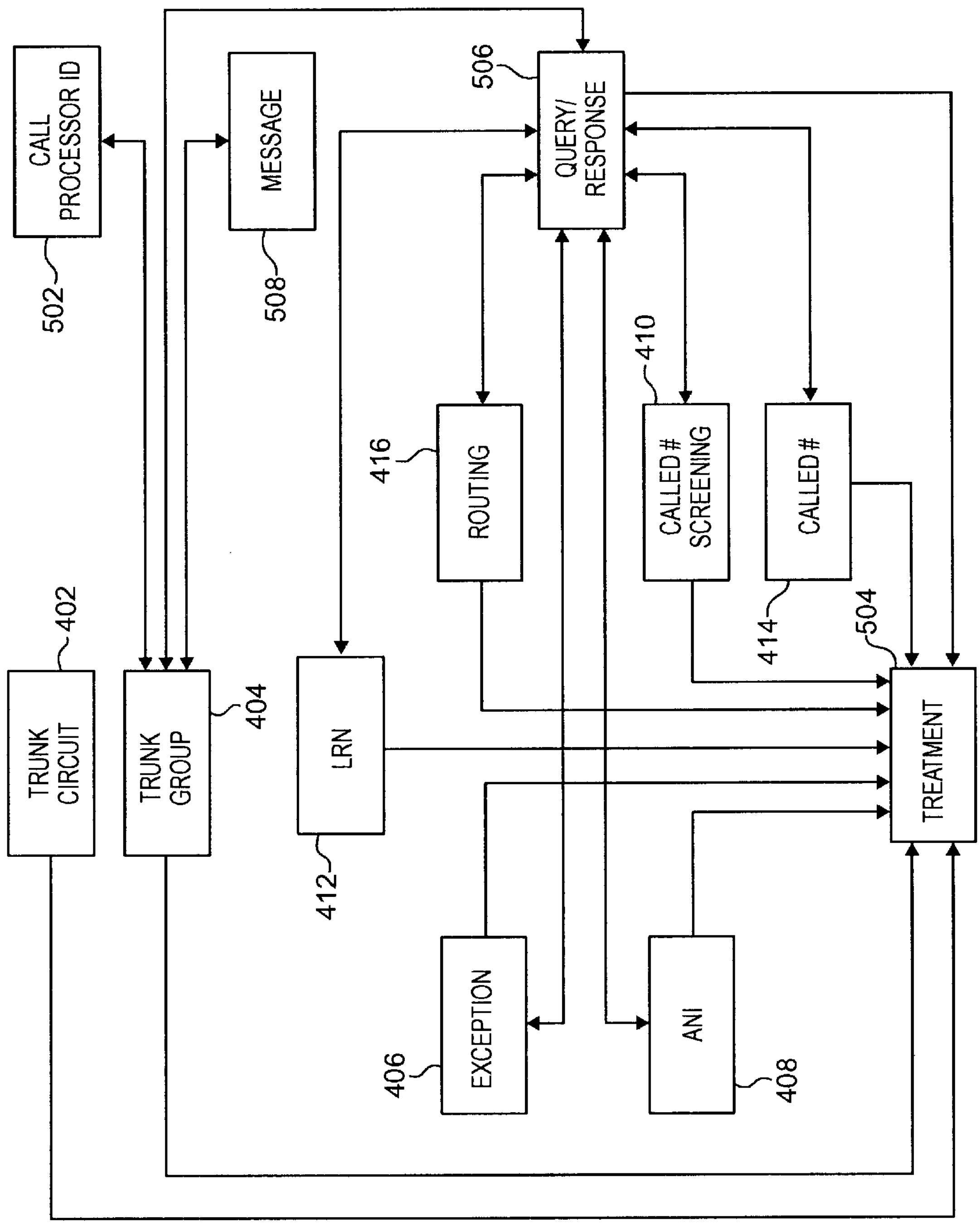

CALL PROCESSOR ID
502
MESSAGE
508
QUERY/ RESPONSE
506
ROUTING
416
CALLED # SCREENING
410
CALLED #
414
TRUNK CIRCUIT
402
TRUNK GROUP
404
LRN
412
TREATMENT
504
EXCEPTION
406
ANI
408

FIG. 5

ASSOCIATED POINT CODE	CIC	VP	VC	TRUNK GROUP NUMBER	GROUP MEMBER NUMBER	HARDWARE IDENTIFIER	ECHO CANCELER	ECHO CONTROL	SATELLITE INDICATOR	CIRCUIT STATUS	CIRCUIT STATE	TIME/ DATE

FIG. 6

TRUNK GROUP NUMBER	GLARE RESOLUTION	CONTINUITY CONTROL	CLLI	SATELLITE TRUNK GROUP	SERVICE INDICATOR	NPA	SEL SEQ	HOP COUNTER	ACC ACTIVE	RE-ATTEMPT CIRCUIT	DEFAULT JIP/LRN	OMI	NEXT FUNCTION	NEXT INDEX

FIG. 7

EXCEPTION TABLE INDEX	CARRIER SELECTION IDENTIFICATION	CARRIER IDENTIFICATION	CALLED PARTY			NEXT FUNCTION	NEXT INDEX
			NATURE OF ADDRESS	DIGITS FROM	DIGITS TO		

FIG. 8

ANI TABLE INDEX	CALLING PARTY CATEGORY	CALLING PARTY/CHARGE NUMBER				ORIGINATING LINE INFORMATION	NEXT FUNCTION	NEXT INDEX
		NATURE OF ADDRESS	DIGITS FROM	DIGITS TO	DATA			

FIG. 9

CALLED NUMBER SCREENING TABLE INDEX	NATURE OF ADDRESS	DIGITS FROM	DIGITS TO	NEXT FUNCTION	NEXT INDEX

FIG. 10

LRN TABLE INDEX	NATURE OF ADDRESS	DIGITS FROM	DIGITS TO	NEXT FUNCTION	NEXT INDEX

FIG. 11

CALLED NUMBER TABLE INDEX	NATURE OF ADDRESS	DIGITS FROM	DIGITS TO	NEXT FUNCTION	NEXT INDEX

FIG. 12

ROUTING TABLE INDEX	TRANSIT NETWORK SELECTION			NEXT FUNCTION #1	INDEX #1	SIGNAL ROUTE	NEXT FUNCTION #2	INDEX #2	SIGNAL ROUTE	NEXT FUNCTION #3	INDEX #3	SIGNAL ROUTE
	NETWORK IDENTIFICATION PLAN	DIGITS	CIRCUIT CODE									

FIG. 13

TREATMENT TABLE INDEX	MESSAGE RECEIVED CAUSE VALUE	GENERAL LOCATION	CODING STANDARD	CAUSE VALUE	NEXT FUNCTION	NEXT INDEX

FIG. 14

MESSAGE TYPE	PARAMETERS	INDEX #1	INDEX #...	INDEX #N
ADDRESS COMPLETE	BACKWARD CALL INDICATOR			
	ACCESS TRANSPORT			
	CAUSE INDICATOR			
	PRIVATE OPTIONAL			
ANSWER	ACCESS TRANSPORT			
	BACKWARD CALL INDICATOR			
	PRIVATE OPTIONAL			
CALL PROGRESS	EVENT INFORMATION			
	BACKWARD CALL INDICATOR			
	ACCESS TRANSPORT			
	CAUSE INDICATOR			
	OPTIONAL BACKWARD CALL INDICATOR			
CIRCUIT RESERVATION	NATURE OF CONNECTION INDICATOR			
CIRCUIT RESERVATION ACK	N/A			
CONFUSION	N/A			
CONTINUITY	CONTINUITY INDICATOR			
EXIT	OUTGOING TRUNK GROUP NUMBER			
INFORMATION	ALL PARAMETERS			
INFORMATION REQUEST	ALL PARAMETERS			
INITIAL ADDRESS	LNP SIGNALING INSTRUCTION PARAMETER			
	NATURE OF CONNECTION INDICATOR			
	FORWARD CALL INDICATOR			
	CALLING PARTY'S CATEGORY			
	USER SERVICE INFORMATION			
	CALLED PARTY NUMBER			
	ACCESS TRANSPORT			
	CALLING PARTY NUMBER			
	CARRIER IDENTIFICATION			
	CARRIER SELECTION INFORMATION			
	CHARGE NUMBER			
	GENERIC ADDRESS			
	JURISDICTION			
	ORIGINATING LINE INFORMATION			
	ORIGINAL CALLED NUMBER			
	REDIRECTING NUMBER			
	SERVICE CODE			
	TRANSIT NETWORK SELECTION			
	HOP COUNTER			
PASS ALONG	ALL PARAMETERS			
RELEASE	CAUSE INDICATOR			
	ACCESS TRANSPORT			
	AUTOMATIC CONGESTION CONTROL			
RELEASE COMPLETE	N/A			
RESUME	SUSPEND/RESUME INDICATOR			
SUSPEND	SUSPEND/RESUME INDICATOR			

FIG. 15

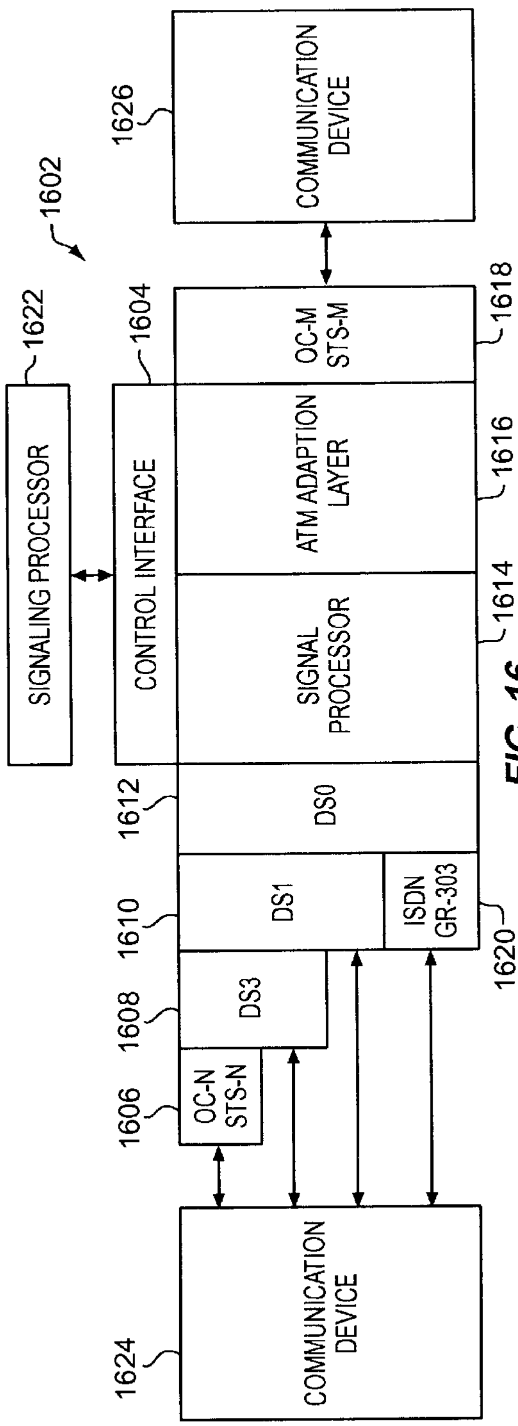

1602
1626
COMMUNICATION DEVICE
1622
SIGNALING PROCESSOR
1604
CONTROL INTERFACE
OC-M STS-M
1618
ATM ADAPTION LAYER
1616
SIGNAL PROCESSOR
1614
DS0
1612
DS1
1610
ISDN GR-303
1620
DS3
1608
OC-N STS-N
1606
COMMUNICATION DEVICE
1624

FIG. 16

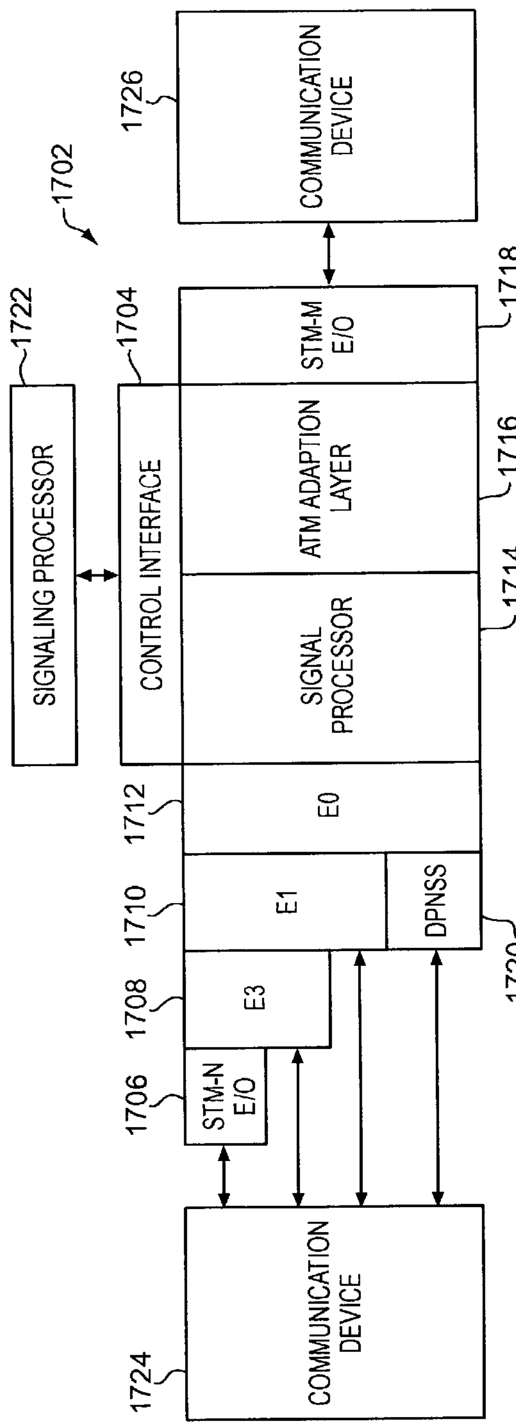

1702
1726
COMMUNICATION DEVICE
1722
SIGNALING PROCESSOR
1704
CONTROL INTERFACE
STM-M E/O
1718
ATM ADAPTION LAYER
1716
SIGNAL PROCESSOR
1714
E0
1712
E1
1710
DPNSS
1720
E3
1708
STM-N E/O
1706
COMMUNICATION DEVICE
1724

FIG. 17

TELECOMMUNICATIONS SYSTEM ARCHITECTURE FOR CONNECTING A CALL

RELATED APPLICATIONS

Not Applicable

FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not Applicable

MICROFICHE APPENDIX

Not Applicable

FIELD OF THE INVENTION

The present invention relates to the field of telecommunications call switching and transport in a system that provides asynchronous transfer mode connections.

BACKGROUND OF THE INVENTION

Broadband systems are being developed to provide telecommunications providers with many benefits, including more efficient use of network bandwidth and the ability to integrate voice, data, and video communications. Broadband systems provide telecommunications network users with increased capabilities at lower costs.

Telecommunications architectures provide call switching and call connections by processing signaling to determine the origination and destination of a call and by selecting a route or connection for the call. This call connection must be completed for local exchange companies as well as interexchange companies. In addition, the call is processed with services before, during, and after the call is connected. Some of these services include N00, calling card, and accounting system services.

Existing telecommunications architectures are not readily scaleable. Furthermore, it is not convenient to change the services provided by the devices in the architecture. Therefore, there is a need for a telecommunications architecture that is scaleable and that can be programmed and maintained easily by a service provider. There is a need for such an architecture to provide a myriad of intelligent network services in a cost efficient manner.

SUMMARY OF THE INVENTION

The present invention comprises a system for connecting a call comprising a call processor adapted to receive call information elements and to process the call information elements and call-associated data to select a connection for the call. The call processor transports a control message identifying the selected connection. A signaling interface is adapted to receive the call signaling, to process the call signaling to isolate the call information elements, and to transfer the call information elements to the call processor. A call process control system is adapted to manage the call-associated data and to exchange the call-associated data with the call processor. An interworking unit is adapted to receive the control message from the call processor, to receive user communications, and to interwork the user communications to the selected connection according to the control message.

The present invention further comprises a system for connecting a call comprising a call processor adapted to

receive call information elements and to process the call information elements and call-associated data to select a connection for the call. The call processor transports a control message identifying the selected connection. A signaling interface is adapted to receive the call signaling, to process the call signaling to isolate the call information elements and to transfer the call information elements to the call processor. A call process control system is adapted to manage the call-associated data and to exchange the call-associated data with the call processor.

The present invention further comprises a method for connecting a call through an asynchronous transfer mode system comprising receiving call-associated data and managing the call-associated data to be used for processing information parameters to select a connection. The call-associated data is moved to a data structure in a call processor. The call signaling is received and processed to the isolate information parameters in the call signaling. The information parameters are moved from the call process control system to the call processor. The information parameters are processed in the call processor using the call-associated data to select a connection for the call and transported a control message identifying the selected connection.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of an architecture for connecting calls in accordance with one embodiment of the present invention.

FIG. **2** is a block diagram of an architecture for connecting calls with a plurality of call processors and with redundancy in accordance with one embodiment of the present invention.

FIG. **3** is a block diagram of the architecture of FIG. **1** interfacing with systems in accordance with an embodiment of the present invention.

FIG. **4** is a block diagram of a data structure having tables that are used in the call processor of FIG. **3**.

FIG. **5** is a block diagram of additional tables that are used in the call processor of FIG. **3**.

FIG. **6** is a table diagram of a trunk circuit table used in the call processor of FIG. **3**.

FIG. **7** is a table diagram of a trunk group table used in the call processor of FIG. **3**.

FIG. **8** is a table diagram of an exception circuit table used in the call processor of FIG. **3**.

FIG. **9** is a table diagram of an automated number index table used in the call processor of FIG. **3**.

FIG. **10** is a table diagram of a called number screening table used in the call processor of FIG. **3**.

FIG. **11** is a table diagram of a local routing number table used in the call processor of FIG. **3**.

FIG. **12** is a table diagram of a called number table used in the call processor of FIG. **3**.

FIG. **13** is a table diagram of a routing table used in the call processor of FIG. **3**.

FIG. **14** is a table diagram of a treatment table used in the call processor of FIG. **3**.

FIG. **15** is a table diagram of a message table used in the call processor of FIG. **3**.

FIG. **16** is a functional diagram of an asynchronous transfer mode interworking unit for use with a synchronous optical network system in accordance with the present invention.

FIG. **17** is a functional diagram of an asynchronous transfer mode interworking unit for use with a synchronous digital hierarchy system in accordance with the present invention.

DETAILED DESCRIPTION

Telecommunication systems have a number of communication devices in local exchange and interexchange environments that interact to provide call services to customers. Both traditional and intelligent network (IN) services and resources are used to process, route, or connect a call to a designated connection.

A call has user communications and call signaling. The user communications contain the caller's information, such as a voice communication or data communication, which is transported over a connection. Call signaling contains information that facilitates call processing, and it is communicated over a link. Call signaling contains, for example, information describing the called number and the calling number. Examples of call signaling are standardized signaling, such as signaling system #7 (SS7), C7, integrated services digital network (ISDN), and digital private network signaling system (DPNSS), which are based on ITU recommendation Q.933. A call can be connected to and from communication devices.

The present invention provides a telecommunications architecture for connecting calls in and between local exchange systems and interexchange systems. The telecommunications architecture provides IN call processing and is scaleable so that it can be applied in small and large systems.

FIG. **1** illustrates an architecture system **102** according to the present invention. Architecture system **102** comprises a call processor **104**, a signaling interface **106**, a call process control system (CPCS) **108**, and an interworking unit **110**. Architecture system **102** is connected to first communication device **112** and second communication device **114**. CPCS **108** is connected to operations systems **116**.

It will be appreciated that the elements of the architecture system **102** may be logical or physical entities. In addition, other elements may be connected to the architecture system, but are not shown for clarity. For example, signaling interface **106** may be linked to a signal transfer point (STP) or a service control point (SCP).

Call processor **104** is linked to CPCS **108** by link **118**, to signaling interface **106** by link **120**, and to interworking unit **110** by link **122**. CPCS **108** is linked to signaling interface **106** by link **124**, to interworking unit **110** by link **126**, and to operations systems **116** by link **128**. Link **130** extends between signaling interface **106** and first communications device **112**. Another link **132** extends from signaling interface **106**. In some cases, link **132** extends to second communication device **114**. Interworking unit **110** is connected to first communication device **112** by connection **134** and to second communication device **114** by connection **136**.

Links are used to transport call signaling and control messages. The term "link" as used herein means a transmission media that may be used to carry call signaling and control messages containing, for example, device instructions and data. A link can carry, for example, out-of-band signaling such as that used in SS7, C7, ISDN, DPNSS, BISDN, GR-303, via local area network (LAN), or data bus call signaling. A link can be, for example, an AAL5 data link, FDDI, ethernet, DS0, or DS1. In addition, a link, as shown in the figures, can represent a single physical link or multiple links, such as one link or a combination of links of ISDN, SS7, TCP/IP, or some other data link. The term "control message" as used herein means a control or signaling message, a control or signaling instruction, or a control or signaling signal, whether proprietary or standardized, that conveys information from one point to another.

Connections are used to transport user communications and other device information between communication devices and between elements and devices of architecture system **102**. The term "connection" as used herein means transmission media that may be used to carry user communications between elements of architecture system **102** and to other devices. For example, a connection could carry a user's voice, computer data, or other communication device data. A connection can be associated with either in-band communications or out-of-band communications.

Call processor **104** includes a signaling platform that can receive and process call signaling. Call processor **104** has data tables which have call connection data and which are used to process the call signaling. Based on the processed call signaling, call processor **104** selects processing options, services, or resources for the user communications and generates and transmits control messages that identify the communication device, processing option, service, or resource that is to be used. Call processor **104** also selects virtual connections and circuit-based connections for call routing and generates and transports control messages that identify the selected connections.

Signaling interface **106** receives, processes, and transmits call signaling. Signaling interface **106** can obtain information from, and transmit information to, a communication device. Such information may be transferred, for example, as a transaction capabilities application part (TCAP) message in queries or responses. Signaling interface **106** also passes information to call processor **104** for processing and passes information from call processor **104** to other communication devices (not shown).

CPCS **108** is a management and administration system. CPCS **108** includes a user interface and an external systems interface into call processor **104**. CPCS **108** serves as a collection point for call-associated data such as translations having call routing data, logs, operational measurement data, alarms, statistical information, accounting information, and other call data. CPCS **108** accepts data, such as the translations, from operations systems **116** and updates the data in the tables in call processor **104**. CPCS **108** also provides configuration data to various elements of the architecture system **102** including call processor **104**, signaling interface **106**, and interworking unit **110**. In addition, CPCS **108** provides for remote control of call monitoring and call tapping applications from call processor **104**.

Interworking unit **110** interworks traffic between various protocols. Preferably, interworking unit **110** interworks between asynchronous transfer mode (ATM) traffic and non-ATM traffic. Interworking unit **110** operates in accordance with control messages received from call processor **104** over link **122**. These control messages typically are provided on a call-by-call basis and typically identify an assignment between a DS0 and a VP/VC for which user communications are interworked. In some instances, interworking unit **110** may transport control messages which may include data.

Communication devices **112** and **114** may include customer premises equipment (CPE), a service platform, a switch, an exchange carrier, a remote digital terminal, an ATM device, or any other device capable of initiating, handling, or terminating a call. CPE may include, for

example, a telephone, a computer, a facsimile machine, or a private branch exchange. A service platform can be, for example, any enhanced computer platform that is capable of processing calls. A remote digital terminal is a device that concentrates analog twisted pairs from telephones and other like devices and converts the analog signals to a digital format known as GR-303.

Operations systems **116** transports translations and other call-associated data to CPCS **108**. In addition, operations systems **116** accepts call-associated data from CPCS **108**. Operations systems **116** may include, for example, an alarm monitoring system that receives alarm data, an operations report system to receive trending data, an accounting system to receive accounting data, or a configuration system to transport routing translations or element configuration data to CPCS **108**. Operations systems **116** may comprise other elements.

The system of FIG. **1** operates as follows. Translations and other data are transported to CPCS **108** from operations systems **116** over link **128**. In addition, CPCS **108** transports data to operations systems **116** over link **128**, if required.

CPCS **108** processes the data and organizes the data into tables that are identical to call processing tables located in call processor **104**. Then, CPCS **108** data fills the call processing tables in call processor **104** over link **116**. In addition, CPCS **108** transports data to any device or entity to which it is configured to transport the data. This data fill may be completed at any time, and updates may be transported from CPCS **108** to call processor **104**.

If any configuration of call processor **104**, signaling interface **106**, or interworking unit **110** is required by CPCS **108**, that configuration information is transported to the appropriate element. In addition, alarms from call processor **104**, signaling interface **106**, or interworking unit **110** are transported to CPCS **108**.

First communication device **112** transports call signaling to signaling interface **106** over link **130**. First communication device **112** transports the user communications to interworking unit **110** over connection **134**.

Signaling interface **106** receives the call signaling and processes the call signaling. Signaling interface **106** passes call information elements received from the call signaling to call processor **104** over link **120**.

Call processor **104** processes the call information elements to select a connection **136**. The selected connection **136** is preferably a VP/VC. However, it will be appreciated that the selected connection also may be a DS0 or other time-division multiplex (TDM) connection. Call processor **104** sends a first control message to interworking unit **110** over link **122** identifying the selected connection **136** over which user communications will be transported. Call processor **104** also sends a second control message to signaling interface **106** over link **120** destined for another communication device identifying the selected connection **136** over which user communications are to be interworked. The other communication device may be, for example, another call processor or a switch which may handle call signaling.

Signaling interface **106** receives the second control message and processes the control message to place it into a transportable form. In some instances, the control message is converted to an SS7 message. Signaling interface **106** transports the second control message over link **132**.

Interworking unit **110** receives user communications from first communication device **112** over connection **134** and the first control message from call processor **104** over link **122**. Interworking unit **110** interworks the user communications between a TDM format and an ATM format according to the first control message. Therefore, interworking unit **110** converts user communications from TDM user communications to ATM cells that identify selected connection **136** and transports the ATM cells over the selected connection **136** to second communication device **114**.

FIG. **2** illustrates an embodiment of an architecture system **202** according to the present invention that includes redundant elements. Redundant elements may be used to maintain call processing capability in the event a main element is defective or otherwise out of service and cannot complete its functions. Architecture system **202** may have N+1 protection.

FIG. **2** illustrates an architecture system **202** comprising a first main call processor **204**, a first backup call processor **204A**, a first main signaling interface **206**, a first backup signaling interface **206A**, a main CPCS **208**, a backup CPCS **208A**, a first main interworking unit **210**, a first backup interworking unit **210A**, a second main call processor **212**, a second backup call processor **212A**, a second main signaling interface **214**, a second backup signaling interface **214A**, a second main interworking unit **216**, and a second backup interworking unit **216A**. Architecture system **202** is connected to first communication device **218** and second communication device **220**. The elements of architecture system **202** are the same as the elements of architecture system **102** of FIG. **1**, and they are linked and connected as described in the text associated with FIG. **1**. However, the links and connections are not referenced with a reference number for clarity.

Thus, for example, first backup call processor **204A** has the same call processing capability, data tables, data structures, and data as first main call processor **204**. If first main call processor **204** is unable to process the call information elements to select connections and to complete other processing, because the first main call processor is defective or otherwise is not operating correctly, then first backup call processor **204A** may take over call processing without an interruption of service. Signaling interfaces **206**, **206A**, **214**, and **214A**, CPCSs **208** and **208A**, interworking units **210**, **210A**, **216**, and **216A**, and second call processors **212** and **212A** also have this redundant structure for their respective operations.

FIG. **3** more fully illustrates the architecture system **102** illustrated in FIG. **1**. Other versions also are contemplated. In the embodiment depicted in FIG. **3**, architecture system **102** includes a signaling interface **304**, a CPCS **306**, and a call processor **308**. It will be appreciated that the elements of architecture system **102** may be constructed as modules in a single unit or as multiple units.

Signaling interface **304** is coupled externally to signaling systems—in particular to signaling systems having a message transfer part (MTP), an ISDN user part (ISUP), a signaling connection control part (SCCP), an intelligent network application part (INAP) and a TCAP. Signaling interface **304** preferably is a platform that comprises an MTP level **1** **310**, an MTP level **2** **312**, and MTP level **3** **314**, an SCCP process **316**, an ISUP process **318**, and a TCAP process **320**. Signaling interface **304** also has INAP functionality (not shown). Signaling interface **304** may be linked to a communication device **322**. For example, communication device **322** may be an SCP which is queried by the signaling interface with an AIN 0.1 SCP TCAP query to obtain additional call-associated data. The answer message may have additional information parameters that are required to complete call processing. Communication device **322** also may be an STP or other device.

Signaling interface **304** is operational to transmit, process, and receive call signaling. The TCAP, SCCP, ISUP, and INAP functionality use the services of MTP to transmit and receive the messages. Preferably, signaling interface **304** transmits and receives SS7 messages for MTP, TCAP, SCCP, and ISUP. Together, this functionality is referred to as an "SS7 stack," and it is well known. The software required by one skilled in the art to configure an SS7 stack is commercially available. One example is the OMNI SS7 stack from Dale, Gesek, McWilliams & Sheridan, Inc. (the DGM&S company).

The processes of the signaling interface **304** process information that is received in message signal units (MSUs) and convert the information to call information elements that are sent to call processor **308** to be processed. A call information element may be, for example, an ISUP IAM message parameter from the MSU. Signaling interface **304** strips the unneeded header information from the MSU to isolate the message information parameters and passes the parameters to call processor **308** as the call information elements. Examples of these parameters are the called number, calling number, and user service information. Other examples of messages with information elements are an ANM, an ACM, an REL, an RLC, and an INF. In addition, call information elements are transferred from call processor **308** back to signaling interface **304**, and the information elements are reassembled into MSUs and transferred to a signaling point.

CPCS **306** comprises several data structures and interfaces. For example, CPCS **306** may comprise interfaces and structures to and for an operations system having an alarm monitoring system **324**, an operations report system **326**, an accounting system **328**, and a configuration system **330**. CPCS **306** also may have a human-machine interface (HMI) **332**. Typically, the messages and data are sent to CPCS **306** through signaling interface **304**, through HMI **332**, or through the interfaces to the operations system. However, other methods and devices may be used.

CPCS **306** has data tables which have call connection data. CPCS **306** accepts data from configuration systems **330** and updates the data in the CPCS tables. The data from configuration systems **330** may include routing data, such as translations for the data fill in the call processing tables, and equipment configuration data. The data in the call processing tables is used to data fill similar tables in call processor **308**. CPCS **306** receives the data and may process the data to make sure it is in the correct format prior to filling the tables in call processor **308**. CPCS **306** maintains a current, historical, and prospective perspective of the tables that are located in call processor **308**.

CPCS **306** also serves as a collection point for alarms. Alarm information is transferred to CPCS **306**. CPCS **306** then transports alarm messages to the required communication device or alarm monitoring system **324**. For example, CPCS **306** can transport alarms to an operations center.

HMI **332** allows a person to log onto CPCS **306** and to manage data tables or to review data tables in CPCS **306** or to provide maintenance services. Thus, HMI **332** allows access to CPCS **306** for active call processing and passive call processing.

Call processor **308** processes call signaling and controls an ATM interworking unit, such as an ATM interworking multiplexer (mux) that performs interworking of DS0s and VP/VCs. However, call processor **308** may control other communications devices and connections in other embodiments.

Call processor **308** receives and processes telecommunications call signaling, control messages, and customer data to select connections that establish communication paths for calls. In the preferred embodiment, the call processor processes SS7 signaling to select connections for a call. Call processing in the call processor and the associated maintenance that is performed for call processing is described in a U.S. Patent Application entitled "System and Method for Treating a Call for Call Processing" filed on the same date as this application, which is assigned to the same assignee as this patent application, and which is incorporated herein by reference.

In addition to selecting connections, call processor **308** performs many other functions in the context of call processing. It not only can control routing and select the actual connections, but it also can validate callers, control echo cancelers, generate accounting information, invoke intelligent network functions, access remote databases, manage traffic, and balance network loads. One skilled in the art will appreciate how the call processor described below can be adapted to operate in the above embodiments.

Call processor **308** comprises a control platform **334** and an application platform **336**. Each platform **334** and **336** is coupled to the other platform.

Control platform **334** is comprised of various external interfaces including an interworking unit interface, an echo interface, a resource control interface, a call information interface and an operations interface. Control platform **334** is externally coupled to an interworking unit control, an echo control, a resource control, accounting, and operations. The interworking unit interface exchanges messages with at least one interworking unit. These messages comprise DS0 to VP/VC assignments, acknowledgments, and status information. The echo control interface exchanges messages with echo control systems. Messages exchanged with echo control systems might include instructions to enable or disable echo cancellation on particular DS0s, acknowledgments, and status information.

The resource control interface exchanges messages with external resources. Examples of such resources are devices that implement continuity testing, encryption, compression, tone detection/transmission, voice detection, and voice messaging. The messages exchanged with resources are instructions to apply the resource to particular DS0s, acknowledgments, and status information. For example, a message may instruct a continuity testing resource to provide a loopback or to send and detect a tone for a continuity test.

The call information interface transfers pertinent call information to a call information processing system, such as to CPCS **306**. Typical call information includes various accounting information, such as the parties to the call, time points for the call, and any special features applied to the call. One skilled in the art will appreciate how to produce the software for the interfaces in control platform **334**.

Application platform **336** processes signaling information from signaling interface **304** to select connections. The identity of the selected connections are provided to control platform **334** for the interworking unit interface. Application platform **336** is responsible for validation, translation, routing, call control, exceptions, screening, and error handling. In addition to providing the control requirements for the interworking unit, application platform **336** also provides requirements for echo control and resource control to the appropriate interface of the control platform **334**. In addition, application platform **336** generates signaling infor-

mation for transmission by signaling interface **304**. The signaling information might be for ISUP, INAP, or TCAP messages to external network elements. Pertinent information for each call is stored in a call buffer information (CBI) location for the call. The CBI can be used for tracking and accounting the call.

Application platform **336** operates in general accord with the Basic Call Model (BCM) defined by the ITU. An instance of the BCM is created to handle each call. The BCM includes an originating process and a terminating process. Application platform **336** includes a service switching function (SSF) that is used to invoke the service control function (SCF). Typically, the SCF is contained in an SCP. The SCF is queried with TCAP or INAP messages transported by signaling interface **304** which are initiated with information from the SSF in application platform **336**. The originating or terminating processes will access remote databases with intelligent network (IN) functionality via the SSF.

Software requirements for application platform **336** can be produced in specification and description language (SDL) defined in ITU-T Z.100. The SDL can be converted into C code. A real time case tool such as SDT from Telelogic, Inc. or Object Time from Object Time, Inc. can be used. Additional C and C++ code can be added as required to establish the environment.

Call processor **308** may include the above-described software loaded onto a computer. The computer may be a Tandem S4000 using the non-stop Unix operating system and conventional database systems. It may be desirable to utilize the multi-threading capability of a Unix operating system.

From FIG. **3**, it can be seen that application platform **336** processes signaling information to control numerous systems and facilitate call connections and services. SS7 signaling is exchanged between call processor **308** and external components through signaling interface **304**, and control information is exchanged with external systems through control platform **334**. Advantageously, signaling interface **304**, CPCS **306**, and call processor **308** are not integrated into a switch central processing unit (CPU) that is coupled to a switching matrix. Unlike an SCP, the components of signaling processor **302** are capable of processing ISUP messages independently of TCAP queries.

SS7 Message Designations

SS7 messages are well known. Designations for various SS7 messages commonly are used. Those skilled in the art are familiar with the following message designations:

ACM—Address Complete Message
ANM—Answer Message
BLO—Blocking
BLA—Blocking Acknowledgment
CPG—Call Progress
CRG—Charge Information
CGB—Circuit Group Blocking
CGBA—Circuit Group Blocking Acknowledgment
GRS—Circuit Group Reset
GRA—Circuit Group Reset Acknowledgment
CGU—Circuit Group Unblocking
CGUA—Circuit Group Unblocking Acknowledgment
CQM—Circuit Group Query
CQR—Circuit Group Query Response

CRM—Circuit Reservation Message
CRA—Circuit Reservation Acknowledgment
CVT—Circuit Validation Test
CVR—Circuit Validation Response
CFN—Confusion
COT—Continuity
CCR—Continuity Check Request
EXM—Exit Message
INF—Information
INR—Information Request
IAM—Initial Address
LPA—Loop Back Acknowledgment
PAM—Pass Along
REL—Release
RLC—Release Complete
RSC—Reset Circuit
RES—Resume
SUS—Suspend
TCAP—Transaction Capabilities Application Part
UBL—Unblocking
UBA—Unblocking Acknowledgment
UCIC—Unequipped Circuit Identification Code.

Call Processor Tables

Call processing typically entails two aspects. First, an incoming or "originating" connection is recognized by an originating call process. For example, the initial connection that a call uses to enter a network is the originating connection in that network. Second, an outgoing or "terminating" connection is selected by a terminating call process. For example, the terminating connection is coupled to the originating connection in order to extend the call through the network. These two aspects of call processing are referred to as the originating side of the call and the terminating side of the call.

FIG. **4** depicts a data structure used by application platform **336** of FIG. **3** to execute the BCM. This is accomplished through a series of tables that point to one another in various ways. The pointers are typically comprised of next function and next index designations. The next function points to the next table, and the next index points to an entry or a range of entries in that table. The data structure has trunk circuit table **402**, trunk group table **404**, exception table **406**, ANI table **408**, called number screening table **410**, location routing number (LRN) table **412**, called number table **414**, and routing table **416**.

Trunk circuit table **402** contains information related to the connections. Typically, the connections are DS0 or ATM connections. Initially, trunk circuit table **402** is used to retrieve information about the originating connection. Later, the table is used to retrieve information about the terminating connection. When the originating connection is being processed, the trunk group number in trunk circuit table **402** points to the applicable trunk group for the originating connection in trunk group table **404**.

Trunk group table **404** contains information related to the originating and terminating trunk groups. When the originating connection is being processed, trunk group table **404** provides information relevant to the trunk group for the originating connection and typically points to exception table **406**.

Exception table **406** is used to identify various exception conditions related to the call that may influence the routing

or other handling of the call. Typically, exception table **406** points to ANI table **408**. Although, exception table **406** may point directly to trunk group table **404**, called number table **414**, or routing table **416**.

ANI table **408** is used to identify any special characteristics related to the caller's number. The caller's number is commonly known as automatic number identification (ANI). ANI table **408** typically points to called number screening table **410**. Although, ANI table **408** may point directly to trunk group table **404** or routing table **416**.

Called number screening table **410** is used to provide the trigger detection point (TDP) for an AIN 0.1 SCP TCAP query. It is used, for example, with the local number portability (LNP) feature. Called number screening table **410** invokes a TCAP. According to the TCAP response, either LRN table **412** or called number table **414** is accessed.

LRN table **412** is used to identify routing requirements based on the called number for those calls that have a return response from an LNP query to an SCP, indicating that the called number is ported. LRN table **412** points to routing table **416**.

Called number table **414** is used to identify routing requirements based on the called number. This will be the case for standard telephone calls. Called number table **414** typically points to routing table **416**. Although, it may point to trunk group table **404**.

Routing table **416** has information relating to the routing of the call for the various connections. Routing table **416** is entered from a pointer in the exception table **406**, ANI table **408**, LRN table **412**, or called number table **414**. Routing table **416** typically points to a trunk group in trunk group table **404**.

When exception table **406**, ANI table **408**, called number table **414**, or routing table **416** point to trunk group table **404**, they effectively select the terminating trunk group. When the terminating connection is being processed, the trunk group number in trunk group table **404** and trunk circuit table **406** is the index that points to the trunk group index. The trunk group index contains the applicable terminating connection in trunk circuit table **404**.

The terminating trunk circuit is used to extend the call. The trunk circuit is typically a VP/VC or a DS0. Thus, it can be seen that by migrating through the tables, a terminating connection can be selected for a call.

FIG. **5** is an overlay of FIG. **4**. The tables from FIG. **4** are present, but for clarity, their pointers have been omitted. FIG. **5** illustrates additional tables that can be accessed from the tables of FIG. **4**. These include a call processor ID table **502**, a treatment table **504**, a query/response table **506**, and a message table **508**.

Call processor ID table **502** contains various call processor SS7 point codes. It can be accessed from trunk group table **404**, and it points back to trunk group table **404**.

Treatment table **504** identifies various special actions to be taken in the course of call processing. This will typically result in the transmission of a release message (REL) and a cause value. Treatment table **504** can be accessed from trunk circuit table **402**, trunk group table **404**, exception table **406**, ANI table **408**, called number screening table **410**, LRN table **412**, called number table **414**, routing table **416**, and query/response table **506**.

Query/response table **506** has information used to invoke the SCF. It can be accessed by trunk group table **404**, exception table **406**, ANI table **408**, called number screening table **410**, LRN table **412**, called number table **414**, and routing table **416**. It points to trunk group table **404**, exception table **406**, ANI table **408**, called number screening table **410**, LRN table **412**, called number table **414**, routing table **416**, and treatment table **504**.

Message table **508** is used to provide instructions for signaling messages from the termination side of the call. It can be accessed by trunk group table **404** and points to trunk group table **404**.

FIGS. **6–15** depict examples of the various tables described above. FIG. **6** depicts an example of the trunk circuit table. Initially, the trunk circuit table is used to access information about the originating circuit. Later in the processing, it is used to provide information about the terminating circuit. For originating circuit processing, the associated point code is used to enter the table. This is the point code of the switch or call processor associated with the originating circuit. For terminating circuit processing, the trunk group number is used to enter the table.

The table also contains the circuit identification code (CIC). The CIC identifies the circuit which is typically a DS0 or a VP/VC. Thus, the invention is capable of mapping the SS7 CICs to the ATM VP/VC. If the circuit is ATM, the VP and the VC also can be used for identification. The group member number is a numeric code that is used for terminating circuit selection. The hardware identifier identifies the location of the hardware associated with the originating circuit. The echo canceler (EC) identification (ID) entry identifies the echo canceler for the originating circuit.

The remaining fields are dynamic in that they are filled during call processing. The echo control entry is filled based on three fields in signaling messages: the echo suppresser indicator in the IAM or circuit reservation message (CRM), and the information transfer capability in the IAM. This information is used to determine if echo control is required on the call. The satellite indicator is filled with the satellite indicator in the IAM or CRM. It may be used to reject a call if too many satellites are used. The circuit status indicates if the given circuit is idle, blocked, or not blocked. The circuit state indicates the current state of the circuit, for example, active or transient. The time/date indicates when the idle circuit went idle.

FIG. **7** depicts an example of a trunk group table. During origination processing, the trunk group number from the trunk circuit table is used to key into the trunk table. Glare resolution indicates how a glare situation is to be resolved. Glare is dual seizure of the same circuit. If the glare resolution entry is set to "even/odd," the network element with the higher point code controls the even circuits, and the network element with the lower point code controls the odd circuits. If the glare resolution entry is set to "all," the call processor controls all of the circuits. If the glare resolution entry is set to "none," the call processor yields. The continuity control entry lists the percent of calls requiring continuity tests on the trunk group.

Continuity control indicates whether continuity is to be checked. The common language location identifier (CLLI) entry is a Bellcore standardized entry. The satellite trunk group entry indicates that the trunk group uses a satellite. The satellite trunk group entry is used in conjunction with the satellite indicator field described above to determine if the call has used too many satellite connections and, therefore, must be rejected. The service indicator indicates if the incoming message is from a call processor (ATM) or a switch (TDM). The outgoing message index (OMI) points to the message table so that outgoing messages can obtain parameters. The associated number plan area (NPA) entry identifies the area code.

Selection sequence (SEL SEQ) indicates the methodology that will be used to select a connection. The selection sequence field designations tell the trunk group to select circuits based on the following: least idle, most idle, ascending, descending, clockwise, and counterclockwise. The hop counter is decremented from the IAM. If the hop counter is zero, the call is released. Automatic congestion control (ACC) active indicates whether or not congestion control is active. If automatic congestion control is active, the call processor may release the call. During termination processing, the next function and index are used to enter the trunk circuit table. Reattempt circuit indicates if an outgoing call can be reattempted on a different circuit within the same trunk group.

Default jurisdiction information parameter (JIP) is an NPA-NXX value that is used to identify the switch from which the call originates. If an ISUP JIP is not received in an IAM, the default JIP is the value recorded on the call processor CBI. Alternately, this field can hold a default LRN having a ten digit form of NPA-NXX-XXXX in which the first six digits can populate the JIP parameter. If an ISUP LRN is not received in an IAM, the default IAM is the value recorded on the call processor CBI. The next function and next index entries point to the next table.

FIG. **8** depicts an example of an exception table. The index is used as a pointer to enter the table. The carrier selection identification (ID) parameter indicates how the caller reached the network and is used for routing certain types of calls. The following are used for this field: spare or no indication, selected carrier identification code presubscribed and input by the calling party, selected carrier identification code presubscribed and not input by the calling party, selected carrier identification code presubscribed and no indication of input by the calling party, and selected carrier identification code not presubscribed and input by the calling party. The carrier identification (ID) indicates the network that the caller wants to use. This is used to route calls directly to the desired network.

The called party number nature of address differentiates between 0+ calls, 1+ calls, test calls, and international calls. For example, international calls might be routed to a preselected international carrier. The called party "digits from" and "digits to" focus further processing unique to a defined range of called numbers. The "digits from" field is a decimal number ranging from 1–15 digits. It can be any length and, if filled with less than 15 digits, is filled with 0s for the remaining digits. The "digits to" field is a decimal number ranging from 1–15 digits. It can be any length and, if filled with less than 15 digits, is filled with 9s for the remaining digits. The next function and next index entries point to the next table which is typically the ANI table.

FIG. **9** depicts an example of an ANI table. The index is used to enter the fields of the table. The calling party category differentiates among types of calling parties, for example, test calls, emergency calls, and ordinary calls. The calling party/charge number entry nature of address indicates how the ANI is to be obtained. The following is the table fill that is used in this field: unknown, unique subscriber numbers, ANI not available or not provided, unique national number, ANI of the called party included, ANI of the called party not included, ANI of the called party includes national number, non-unique subscriber number, non-unique national number, non-unique international number, test line test code, and all other parameter values.

The "digits from" and "digits to" focus further processing unique to ANI within a given range. The data entry indicates

if the ANI represents a data device that does not need echo control. Originating line information (OLI) differentiates among ordinary subscriber, multiparty line, ANI failure, station level rating, special operator handling, automatic identified outward dialing, coin or non-coin call using database access, 800\888 service call, coin, prison/inmate service, intercept (blank, trouble, and regular), operator handled call, outward wide area telecommunications service, telecommunications relay service (TRS), cellular services, private paystation, and access for private virtual network types of service. The next function and next index point to the next table which is typically the called number table.

FIG. **10** depicts an example of a called number screening table. The index is used to enter the table. The nature of address entry indicates the type of dialed number, for example, national versus international. The "digits from" and "digits to" entries focus further processing unique to a range of called numbers. This is where the TCAP response information is incorporated in the call processing flow. This is where the trigger occurs for an LNP TCAP query launch. The processing follows the processing logic of the "digits from" and "digits to" fields in FIG. **8**. The next function and next index point to the next table which is typically either the called number table or the LRN table.

FIG. **11** depicts an example of an LRN table. This table will perform the same function as the called number table for those calls that are identified as ported based upon an LNP query response. The index is used to enter the table. The nature of address entry indicates the type of dialed number, for example, national versus international. In an LRN case, the value is a national number. The "digits from" and "digits to" entries focus further processing unique to a range of called numbers. This is where the TCAP response information is incorporated in the call processing flow. The processing follows the processing logic of the "digits from" and "digits to" fields in FIG. **8**. The next function and next index point to the next table which is typically the routing table.

FIG. **12** depicts an example of a called number table. The index is used to enter the table. The called number nature of address entry indicates the type of dialed number, for example, national versus international. The "digits from" and "digits to" entries focus further processing unique to a range of called numbers, and they are used in the LRN table check process. The processing follows the processing logic of the "digits from" and "digits to" fields in FIG. **8**. The next function and next index point to the next table which is typically the routing table.

FIG. **13** depicts an example of the routing table. The index is used to enter the table. The transit network selection (TNS) network identification (ID) plan indicates the number of digits to use for the CIC. The transit network selection "digits" field defines the numbers to identify an international carrier. The circuit code indicates the need for an operator on the call. The next function, next index, and signal route entries in the routing table are used to identify a trunk group. The second and third next function/index/signal route entries define alternate routes. The third next function entry also can point back to another set of next functions in the routing table in order to expand the number of alternate route choices. The only other entries allowed are pointers to the treatment table. If the routing table points to the trunk group table, then the trunk group table typically points to a trunk circuit in the trunk circuit table. The yield from the trunk circuit table is the terminating connection for the call.

It can be seen from FIGS. **6**–**13** that the tables can be configured and relate to one another in such a way that call

processes can enter the trunk circuit table for the originating connection and can traverse through the tables by keying on information and using pointers. The yield of the tables is typically a terminating connection identified by the trunk circuit table. In some cases, treatment is specified by the treatment table instead of a connection. If, at any point during the processing, a trunk group can be selected, processing may proceed directly to the trunk group table for terminating circuit selection. For example, it may be desirable to route calls from a particular ANI over a particular set of trunk groups. In this case, the ANI table would point directly to the trunk group table, and the trunk group table would point to the trunk circuit table for a terminating circuit. The default path through the tables is: trunk circuit, trunk group, exception, ANI, called number screening, called number, routing, trunk group, and trunk circuit.

FIG. **14** depicts an example of a treatment table. Either the index or the message received cause number are filled and are used to enter the table. If the index is filled and used to enter the table, the general location, coding standard, and cause value indicator are used to generate an SS7 REL. The message received cause value entry is the cause value in a received SS7 message. If the message received cause value is filled and used to enter the table, then the cause value from that message is used in an REL from the call processor. The next function and next index point to the next table.

FIG. **15** depicts an example of a message table. This table allows the call processor to alter information in outgoing messages. Message type is used to enter the table, and it represents the outgoing standard SS7 message type. The parameter is the pertinent parameter within the outgoing SS7 message. The indexes point to various entries in the trunk group table and determine if parameters are passed unchanged, omitted, or modified in the outgoing messages.

The ATM Interworking Unit

FIG. **16** shows one embodiment of an interworking unit which is an ATM interworking unit **1602** suitable for the present invention for use with a SONET system, but other interworking units that support the requirements of the invention also are applicable. ATM interworking unit **1602** may receive and transmit in-band and out-of-band calls.

ATM interworking unit **1602** has control interface **1604**, OC-N/STS-N interface **1606**, DS3 interface **1608**, DS1 interface **1610**, DS0 interface **1612**, signal processor **1614**, ATM adaptation layer (AAL) **1616**, OC-M/STS-M interface **1618**, and ISDN/GR-303 interface **1620**. As used herein in conjunction with OC or STS, "N" refers to an integer, and "M" refers to an integer.

Control interface **1604** receives control messages originating from signaling processor **1622**, identifies DS0 and virtual connection assignments in control messages, and provides these assignments to AAL **1616** for implementation. Control messages are received over an ATM virtual connection and through OC-M/STS-M interface **1618** to control interface **1604** or directly through control interface **1604** from a link.

OC-N/STS-N interface **1606**, DS3 interface **1608**, DS1 interface **1610**, DS0 interface **1612**, and ISDN/GR-303 interface **1620** each can receive user communications from communication device **1624**. Likewise, OC-M/STS-M interface **1618** can receive user communications from communication device **1626**.

OC-N/STS-N interface **1606** receives OC-N formatted user communications and STS-N formatted user communications and converts the user communications to the DS3 format. DS3 interface **1608** receives user communications in the DS3 format and converts the user communications to the DSI format. DS3 interface **1608** can receive DS3s from OC-N/STS-N interface **1606** or from an external connection. DS1 interface; **1610** receives the user communications in the DS1 format and converts the user communications to the DS0 format. DS1 interface **1610** receives DS1s from DS3 interface **1608** or from an external connection. DS0 interface **1612** receives user communications in the DS0 format and provides an interface to AAL **1616**. ISDN/GR.303 interface **1620** receives user communications in either the ISDN format or the GR.303 format and converts the user communications to the DS0 format. In addition, each interface may transmit user communications in like manner to communication device **1624**.

OC-M/STS-M interface **1618** is operational to receive ATM cells from AAL **1616** and to transmit ATM cells over the connection to communication device **1626**. OC-M/STS-M interface **1618** also may receive ATM cells in the OC format or the STS format and transmit them to AAL **1616**.

AAL **1616** comprises a convergence sublayer and a segmentation and reassembly (SAR) sublayer. AAL **1616** obtains the identity of the DS0 and the ATM VP/VC from control interface **1604**. AAL **1616** is operational to convert between the DS0 format and the ATM format. AALs are well known in the art; information about AALs is provided by International Telecommunications Union (ITU) document I.363, which is incorporated herein by reference. An AAL for voice calls is described in U.S. Pat. No. 5,606,553 entitled "Cell Processing for Voice Transmission" which is incorporated herein by reference.

Calls with multiple 64 Kilo-bits per second (Kbps) DS0s are known as N×64 calls. If desired, AAL **1616** can be configured to accept control messages through control interface **1604** for N×64 calls. ATM interworking unit **1602** is able to interwork, multiplex, and demultiplex for multiple DS0s. Techniques for processing VP/VCs are disclosed in commonly assigned U.S. patent application Ser. No. 08/653,852, filed on May 28, 1996, and entitled "Telecommunications System with a Connection Processing System," and which is incorporated herein by reference.

DS0 connections are bidirectional, and ATM connections are typically uni-directional. Therefore, two virtual ATM connections in opposing directions typically will be required for each DS0. Those skilled in the art will appreciate how this can be accomplished in the context of the invention. For example, the cross-connect can be provisioned with a second set of VP/VCs in the opposite direction as the original set of VP/VCs.

In some embodiments, it may be desirable to incorporate digital signal processing capabilities at the DS0 level. It may also be desired to apply echo cancellation to selected DS0 circuits. In these embodiments, signal processor **1614** is included either separately (as shown) or as a part of DS0 interface **1612**. Signaling processor **1622** is configured to send control messages to ATM interworking unit **1602** to implement particular features on particular DS0 circuits. Alternatively, lookup tables may be used to implement particular features for particular circuits or VP/VCs.

FIG. **17** shows another embodiment of an interworking unit which is an ATM interworking unit **1702** suitable for the present invention for use with an SDH system. ATM interworking unit **1702** has control interface **1704**, STM-N electrical/optical (E/O) interface **1706**, E3 interface **1708**, E1 interface **1710**, E0 interface **1712**, signal processor **1714**, AAL **1716**, STM-M electrical/optical (E/O) interface **1718**,

and digital private network signaling system (DPNSS) interface **1720**. As used herein in conjunction with STM, "N" refers to an integer, and "M" refers to an integer.

Control interface **1704** receives control messages from the signaling processor **1722**, identifies E**0** and virtual connection assignments in the control messages, and provides these assignments to AAL **1716** for implementation. The control messages are received over an ATM virtual connection and through STM-M interface **1718** to control interface **1604** or directly through control interface **1604** from a link.

STM-N E/O interface **1706**, E**3** interface **1708**, E**1** interface **1710**, E**0** interface **1712**, and DPNSS interface **1720** each can receive user communications from second communication device **1724**. Likewise, STM-M E/O interface **1718** can receive user communications from third communication device **1726**.

STM-N E/O interface **1706** receives STM-N electrical or optical formatted user communications and converts the user communications from STM-N electrical or STM-N optical format to E**3** format. E**3** interface **1708** receives user communications in the E**3** format and converts the user communications to the E**1** format. E**3** interface **1708** can receive E**3**s from STM-N E/O interface **1706** or from an external connection. El interface **1710** receives user communications in the E**1** format and converts the user communications to the E**0** format. E**1** interface **1710** receives E**1**s from STM-N E/O interface **1706** or E**3** interface **1708** or from an external connection. E**0** interface **1712** receives user communications in the E**0** format-and provides an interface to AAL **1716**. DPNSS interface **1720** receives user communications in the DPNSS format and converts the user communications to the E**0** format. In addition, each interface may transmit user communications in a like manner to communication device **1724**.

STM-M E/O interface **1718** is operational to receive ATM cells from AAL **1716** and to transmit ATM cells over the connection to communication device **1726**. STM-M E/O interface **1718** may also receive ATM cells in the STM-M E/O format and transmit them to AAL **1716**.

AAL **1716** comprises both a convergence sublayer and a segmentation and reassembly (SAR) sublayer. AAL **1716** obtains the identity of the E**0** and the ATM VP/VC from, control interface **1704**. AAL **1716** is operational to convert between the E**0** format and the ATM format, either in response to a control instruction or without a control instruction. AAL's are well known in the art. If desired, AAL **1716** can be configured to receive control messages through control interface **1704** for N×64 user communications.

E**0** connections are bidirectional and ATM connections typically are unidirectional. As a result, two virtual connections in opposing directions typically will be required for each E**0**. As described above, those skilled in the art will appreciate how this can be accomplished in the context of the invention.

In some instances, it may be desirable to incorporate digital signal processing capabilities at the E**0** level. Also, it may be desirable to apply echo cancellation. In these embodiments, signal processor **1714** is included either separately (as shown) or as a part of E**0** interface **1712**. Signaling processor **1722** is configured to send control messages to ATM interworking unit **1702** to implement particular features on particular circuits. Alternatively, lookup tables may be used to implement particular features for particular circuits or VP/VCs.

Those skilled in the art will appreciate that variations from the specific embodiments disclosed above are contemplated by the invention. The invention should not be restricted to the above embodiments, but should be measured by the following claims.

What is claimed is:

1. A communication system comprising:

a control system including control system data tables and configured to receive and process call routing data to fill the control system data tables with the call routing data, and to transfer the call routing data from the control system data tables to call processor data tables;

a call processor including the call processor data tables and configured to process signaling information for a call based on the call routing data in the call processor data tables to transfer a control message for the call indicating a first connection and a second connection; and

an interworking unit configured to receive the control message, and in response to the control message, receive user communications in a first format from a first connection, convert the user communications to a second format, and transfer the user communications in the second format over the second connection.

2. The communication system of claim **1** wherein the control system is configured to maintain the control system data tables to format the call routing data for the call processor data tables.

3. The communication system of claim **1** wherein the control system data tables and the call processor data tables are identical.

4. The communication system of claim **1** wherein the control system includes a user interface configured to allow a user to view the control system data tables.

5. The communication system of claim **1** wherein the control system is further configured to transfer the call routing data from the control system data tables to redundant data tables, and further comprising a redundant processor including the redundant data tables and configured to process the signaling information for the call based on the call routing data in the redundant data tables to transfer the control message for the call.

6. The communication system of claim **1** wherein the control system data tables and the call processor data tables each include a called number table.

7. The communication system of claim **1** wherein the call processor is configured to transfer accounting information for the call to the control system.

8. The communication system of claim **1** wherein the call processor is configured to transfer alarm information to the control system.

9. The communication system of claim **1** wherein the first connection comprises a DS0 connection.

10. The communication system of claim **1** wherein the second connection comprises a virtual connection.

11. A method of operating a communication system comprising:

in a control system including control system data tables, receiving and processing call routing data to fill the control system data tables with the call routing data, and transferring the call routing data from the control system data tables to call processor data tables;

in a call processor including the call processor data tables, processing signaling information for a call based on the call routing data in the call processor data tables to transfer a control message for the call indicating a first connection and a second connection; and

in an interworking unit, receiving the control message, and in response to the control message, receiving user

communications in a first format from a first connection, converting the user communications to a second format, and transferring the user communications in the second format over the second connection.

12. The method of claim **11** wherein receiving and processing the call routing data to fill the control system data tables comprises formatting the call routing data for the call processor data tables.

13. The method of claim **11** wherein the control system data tables and the call processor data tables are identical.

14. The method of claim **11** wherein the control system includes a user interface, and further comprising allowing a user to view the control system data tables.

15. The method of claim **11** further comprising transferring the call routing data from the control system data tables to redundant data tables, and in a redundant processor including the redundant data tables, processing the signaling

information for the call based on the call routing data in the redundant data tables to transfer the control message for the call.

16. The method of claim **11** wherein the control system data tables and the call processor data tables each include a called number table.

17. The method of claim **11** further comprising transferring accounting information for the call from the call processor to the control system.

18. The method of claim **11** further comprising transferring alarm information for the call from the call processor to the control system.

19. The method of claim **11** wherein the first connection comprises a DS0 connection.

20. The method claim **11** wherein the second connection comprises a virtual connection.

* * * * *

EXHIBIT O

US006999463B2

(12) **United States Patent**
Christie et al.

(10) **Patent No.: US 6,999,463 B2**
(45) **Date of Patent: *Feb. 14, 2006**

(54) **NUMBER PORTABILITY IN A COMMUNICATIONS SYSTEM**

(75) Inventors: **Joseph Michael Christie**, deceased, late of San Bruno, CA (US); **Joseph S. Christie, legal representative**, Mt. Pleasant, PA (US); **Jean M. Christie, legal representative**, Mt. Pleasant, PA (US); **Michael Joseph Gardner**, Overland Park, KS (US); **Albert Daniel DuRee**, Independence, MO (US); **William Lyle Wiley**, Olathe, KS (US); **Tracy Lee Nelson**, Shawnee Mission, KS (US)

(73) Assignee: **Sprint Communications Company L.P.**, Overland Park, KS (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 181 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **10/635,664**

(22) Filed: **Aug. 6, 2003**
(Under 37 CFR 1.47)

(65) **Prior Publication Data**

US 2004/0057427 A1 Mar. 25, 2004

Related U.S. Application Data

(63) Continuation of application No. 10/077,544, filed on Feb. 15, 2002, now Pat. No. 6,639,912, which is a continuation of application No. 09/272,131, filed on Mar. 19, 1999, now Pat. No. 6,795,440, which is a continuation of application No. 08/755,268, filed on Nov. 22, 1996, now Pat. No. 6,014,378.

(51) **Int. Cl.**
H04L 12/28 (2006.01)
H04L 12/56 (2006.01)

(52) **U.S. Cl.** **370/410**; 370/352; 370/356; 379/221.13

(58) **Field of Classification Search** 370/351–356, 370/395.1, 396–399, 395.2, 395.21, 230, 370/235, 400, 401, 410, 524, 422, 426; 379/221.13–219, 379/220.01, 221.14
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,720,850	A	1/1988	Oberlander et al.
4,754,479	A	6/1988	Bicknell
4,763,317	A	8/1988	Lehman et al.
5,051,983	A	9/1991	Kammerl
5,115,427	A	5/1992	Johnson, Jr. et al.
5,204,857	A	4/1993	Obara
5,278,889	A	1/1994	Papanicolaou et al.
5,291,492	A	3/1994	Andrews et al.
5,327,421	A	7/1994	Hiller et al.
5,329,308	A	7/1994	Binns et al.
5,339,318	A	8/1994	Tanaka et al.
5,345,445	A	9/1994	Hiller et al.
5,375,124	A	12/1994	D'Ambrogio et al.

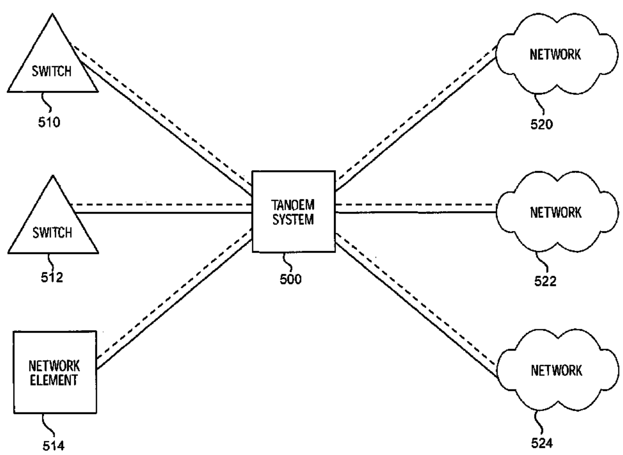
(Continued)

Primary Examiner—Ajit Patel

(57) **ABSTRACT**

A communication system is disclosed comprised of a signaling processor and an interworking system. The signaling processor receives a call setup message including a called number, processes the called number to transmit a query, receives a response message responsive to the query that includes number portability information for the called number, processes the number portability information to select an identifier for routing, and transmits a control message that identifies the identifier. The interworking system receives a user communication and the control message, converts the user communication into communications that include the identifier, and transfers the communications that include the identifier.

20 Claims, 13 Drawing Sheets



U.S. PATENT DOCUMENTS

5,392,402	A		2/1995	Robrock, II	
5,422,882	A		6/1995	Hiller et al.	
5,428,609	A		6/1995	Eng et al.	
5,434,852	A	*	7/1995	La Porta et al.	370/385
5,452,297	A		9/1995	Hiller et al.	
5,461,669	A		10/1995	Vilain	
5,473,677	A		12/1995	D'Amato et al.	
5,473,679	A		12/1995	La Porta et al.	
5,483,527	A	*	1/1996	Doshi et al.	370/399
5,504,744	A		4/1996	Adams et al.	
5,509,010	A	*	4/1996	La Porta et al.	370/397
5,544,163	A		8/1996	Madonna	
5,568,475	A		10/1996	Doshi et al.	
5,592,477	A		1/1997	Farris et al.	
5,606,553	A		2/1997	Christie	
5,623,491	A		4/1997	Skoog	
5,703,876	A		12/1997	Christie	
5,710,769	A		1/1998	Anderson et al.	
5,732,131	A		3/1998	Nimmagadda et al.	
5,751,706	A		5/1998	Land	
5,784,371	A		7/1998	Iwai	
5,793,857	A		8/1998	Barnes et al.	
5,802,045	A		9/1998	Kos	
5,805,588	A		9/1998	Peterson	
5,825,780	A		10/1998	Christie	
5,854,836	A		12/1998	Nimmagadda	
5,867,570	A	*	2/1999	Bargout et al.	379/221.13
5,881,145	A		3/1999	Giuhat et al.	
5,940,393	A		8/1999	Duree et al.	
5,940,491	A		8/1999	Anderson et al.	
5,940,492	A		8/1999	Galloway et al.	
5,949,871	A		9/1999	Kabay et al.	
5,991,301	A		11/1999	Christie	
6,014,378	A		1/2000	Christie	
6,026,091	A		2/2000	Christie et al.	
6,031,840	A		2/2000	Christie et al.	
6,064,887	A		5/2000	Kallioniemi et al.	
6,069,890	A		5/2000	White et al.	
6,078,657	A		6/2000	Alfieri et al.	
6,081,525	A		6/2000	Christie et al.	
6,097,801	A		8/2000	Williams et al.	
6,181,703	B1		1/2001	Christie et al.	
6,272,142	B1		8/2001	Christie et al.	
6,314,096	B1		11/2001	Tanabe et al.	
6,324,179	B1		11/2001	Doshi et al.	
6,411,627	B1		6/2002	Hullett	
6,473,429	B1		10/2002	Christie	
6,618,372	B1		9/2003	Tanabe	
6,639,912	B1		10/2003	Christie et al.	
6,795,440	B1		9/2004	Christie	

* cited by examiner

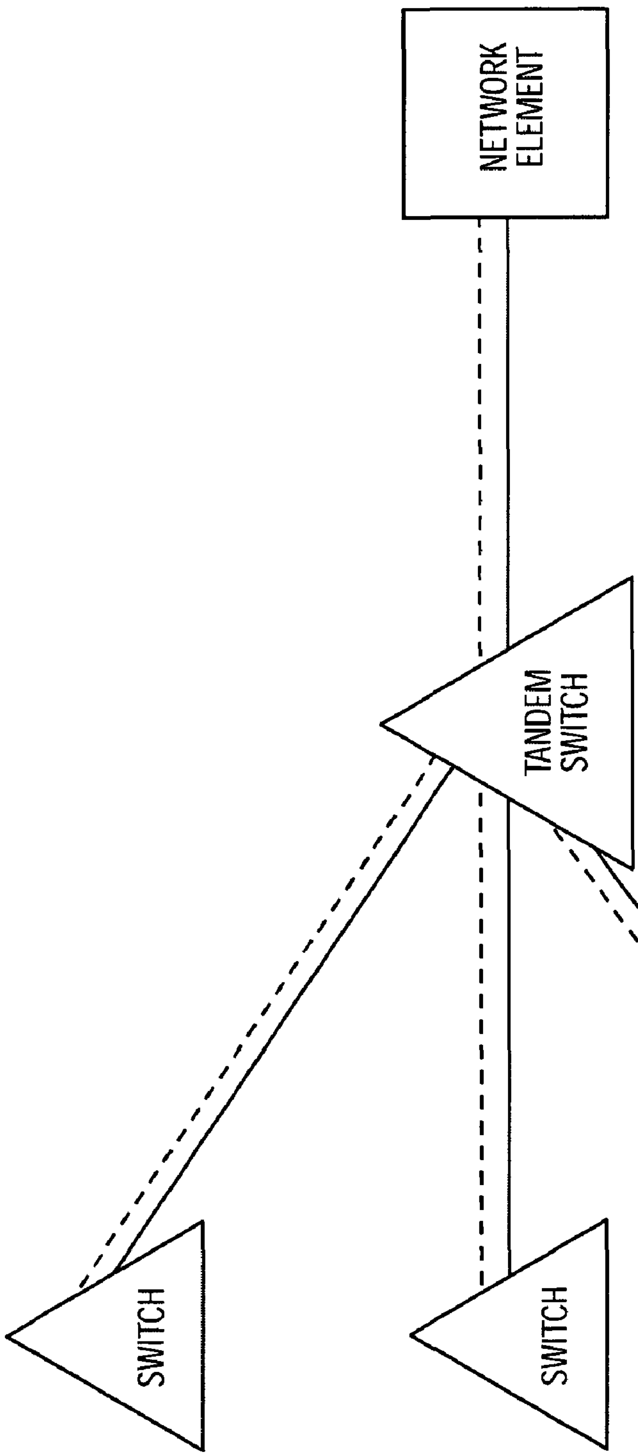
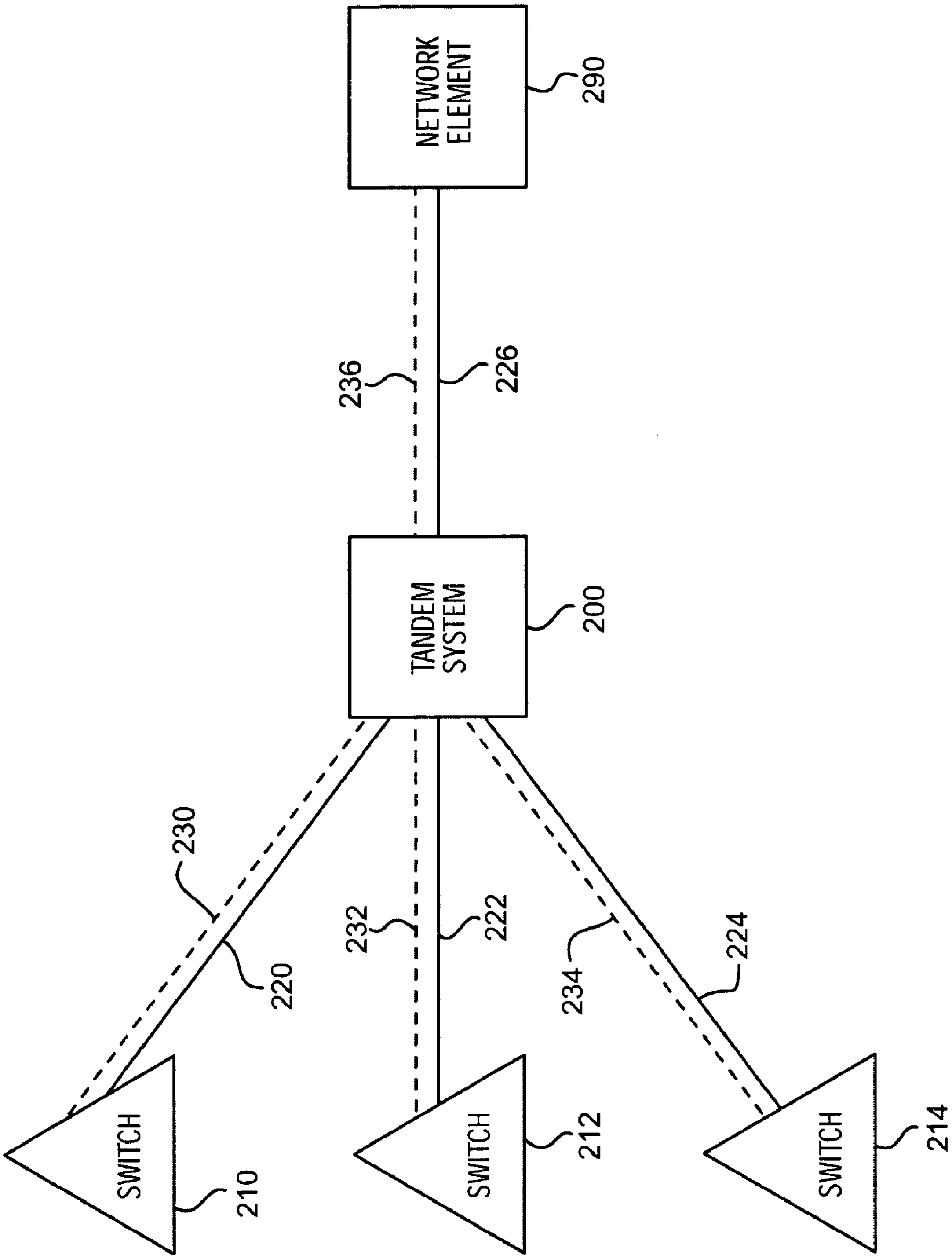


FIG. 1
PRIOR ART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TANDEM SYSTEM
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230
232
222
220
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SWITCH
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SWITCH
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SWITCH
214

FIG. 2

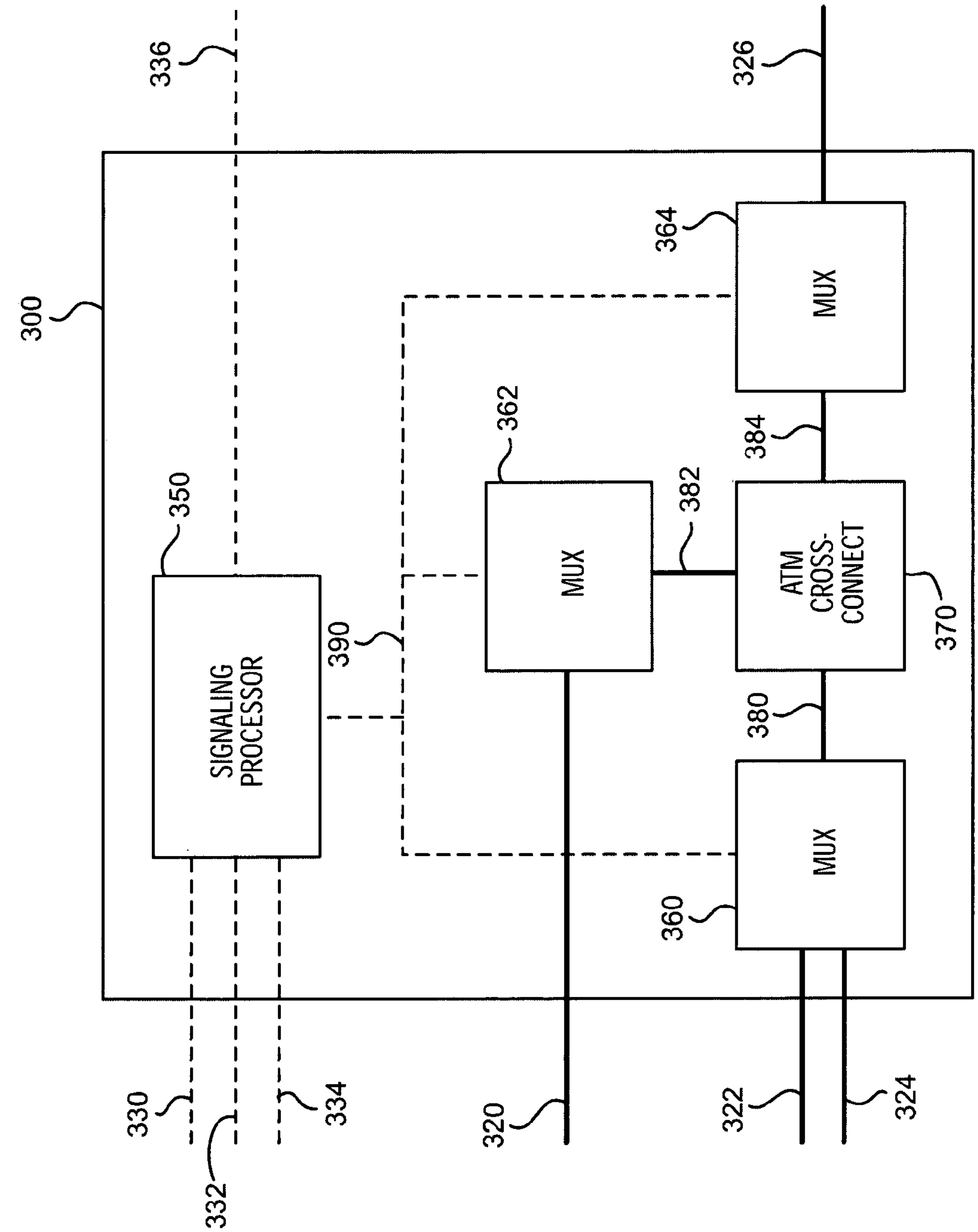

300
336
326
364
MUX
362
384
350
382
SIGNALING PROCESSOR
390
MUX
ATM CROSS-CONNECT
370
380
MUX
360
330
332
334
320
322
324

FIG. 3

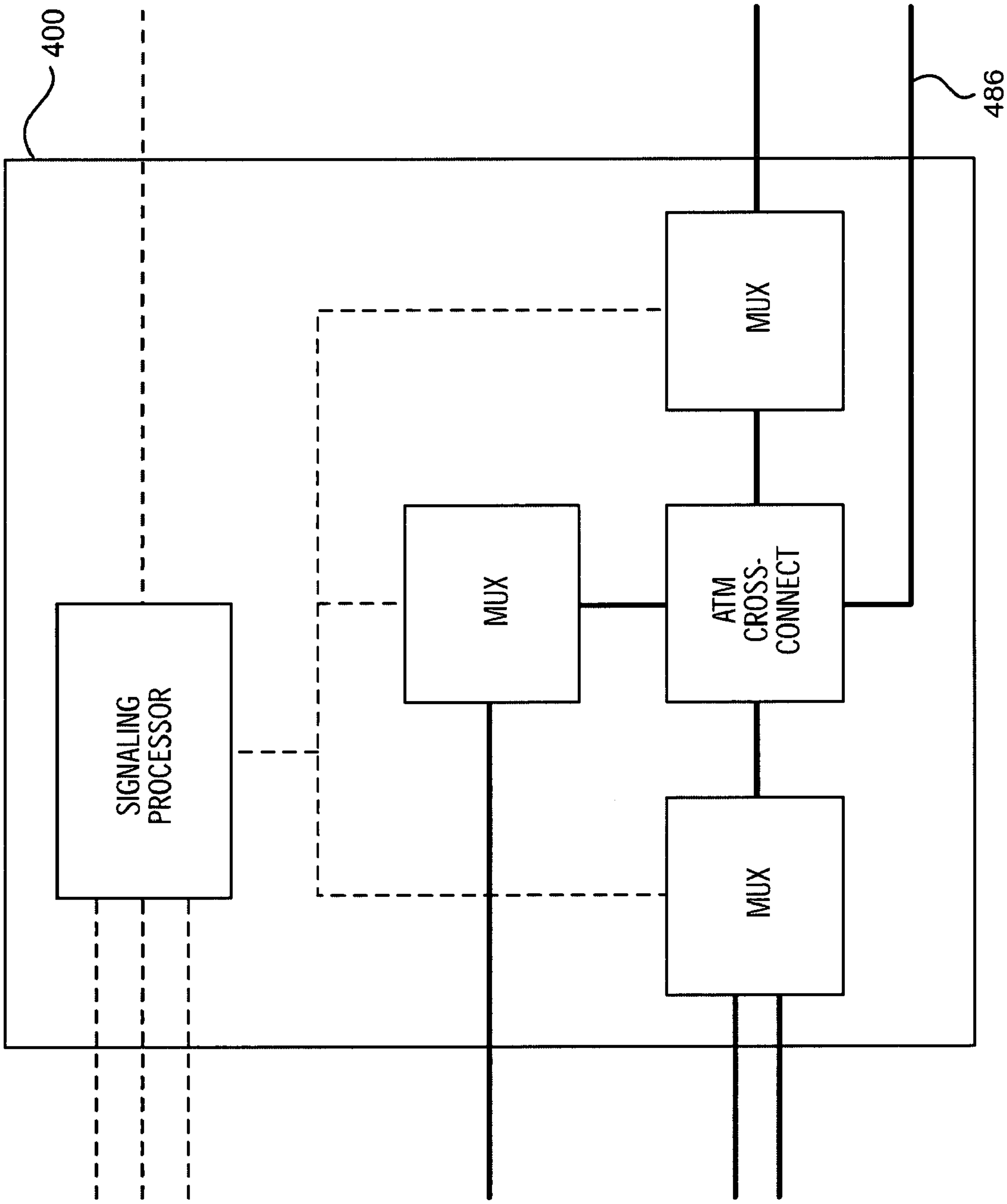
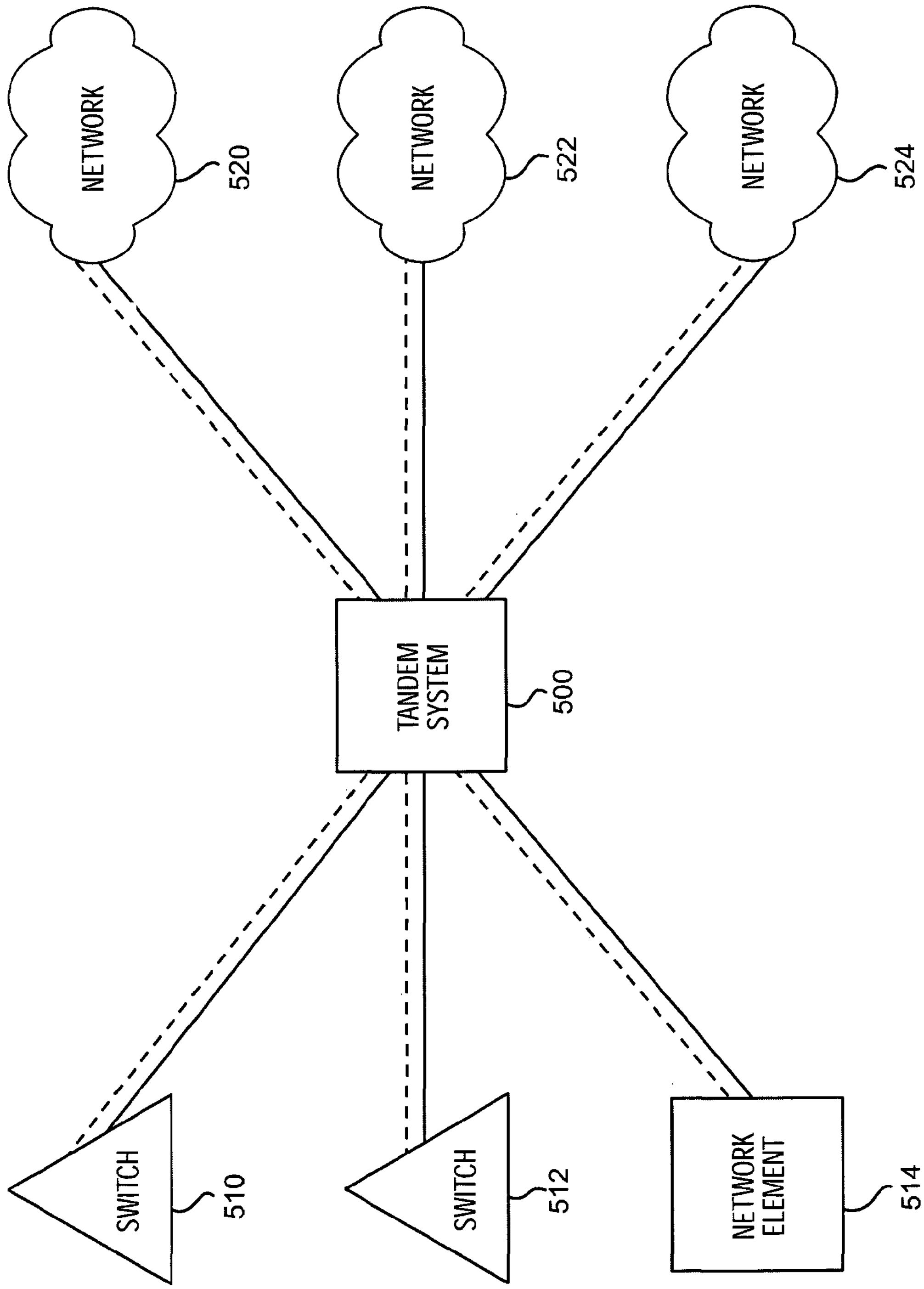


FIG. 4


NETWORK
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NETWORK
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NETWORK
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TANDEM SYSTEM
500
SWITCH
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SWITCH
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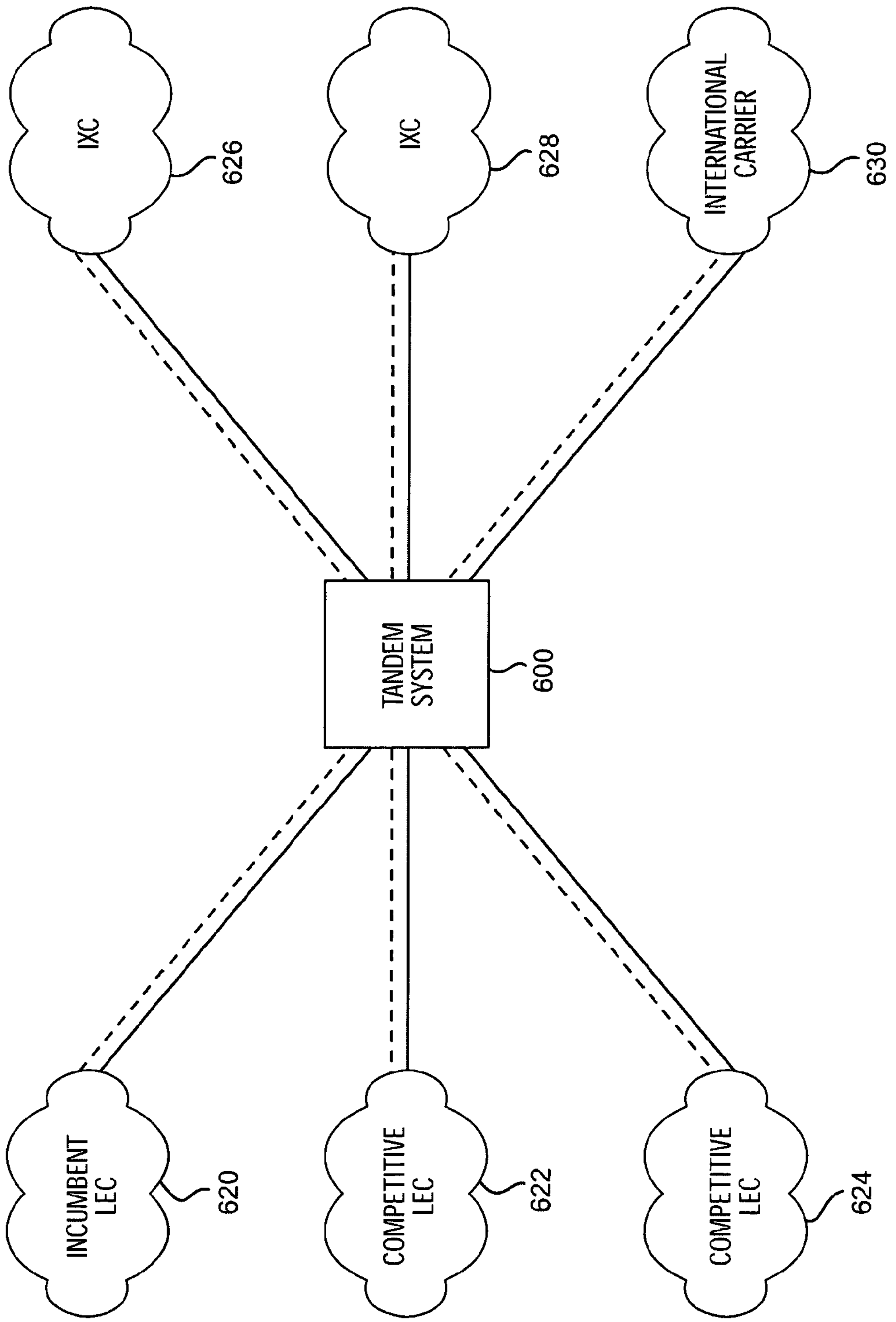
NETWORK ELEMENT
514

FIG. 5


IXC
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IXC
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INTERNATIONAL CARRIER
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TANDEM SYSTEM
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INCUMBENT LEC
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COMPETITIVE LEC
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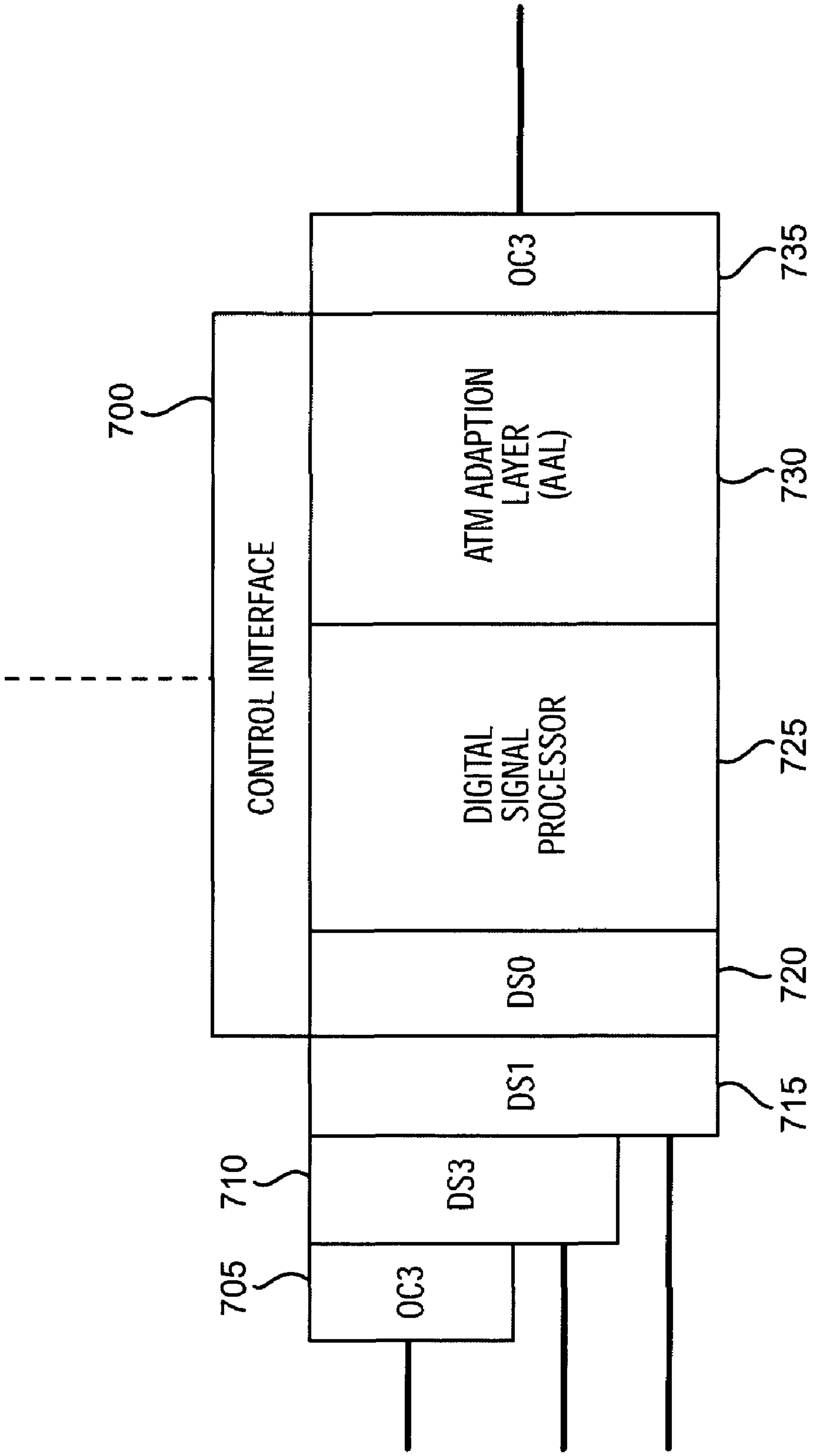
COMPETITIVE LEC
624

FIG. 6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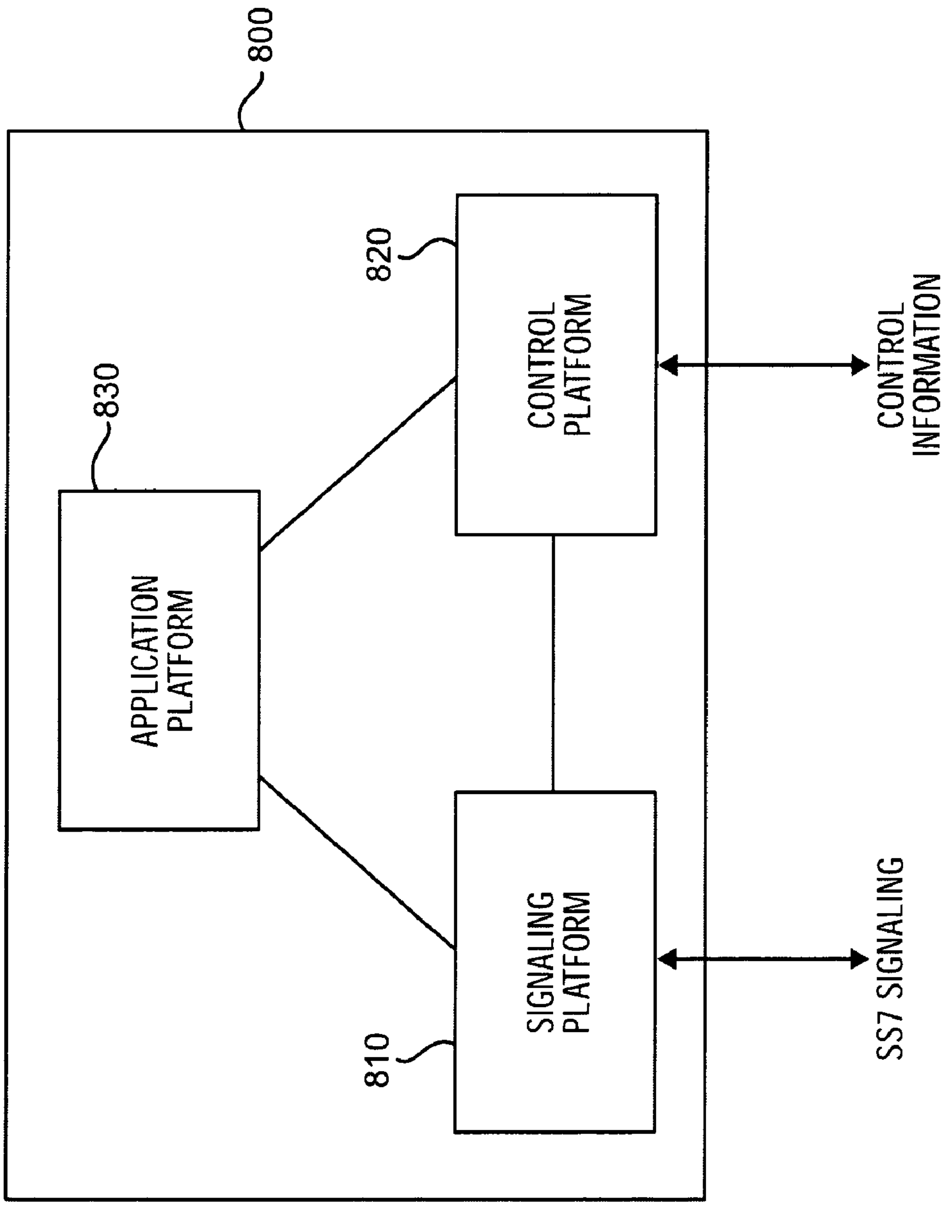
CONTROL INTERFACE
OC3
ATM ADAPTION LAYER (AAL)
DIGITAL SIGNAL PROCESSOR
DS0
DS1
DS3
OC3
735
730
725
720
715
710
705

FIG. 7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APPLICATION PLATFORM
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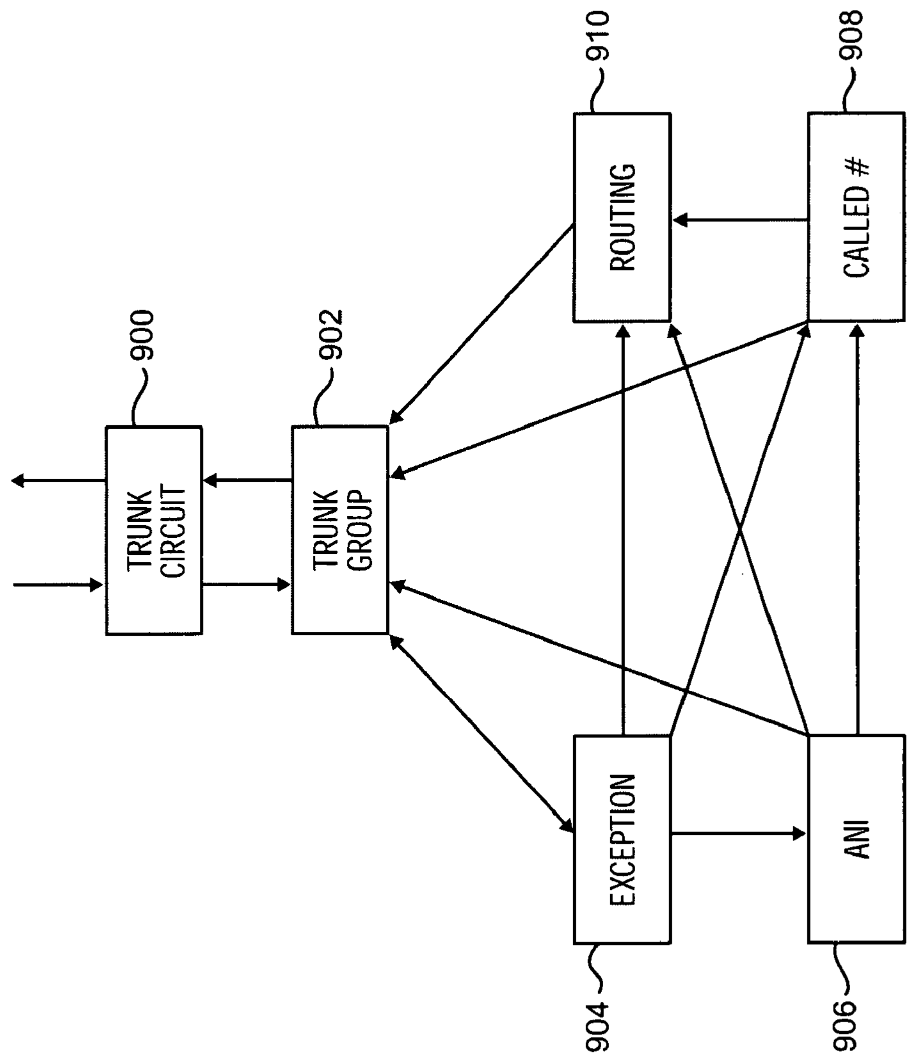
CONTROL PLATFORM
810
SIGNALING PLATFORM
CONTROL INFORMATION
SS7 SIGNALING

FIG. 8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TRUNK GROUP
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ROUTING
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CALLED #
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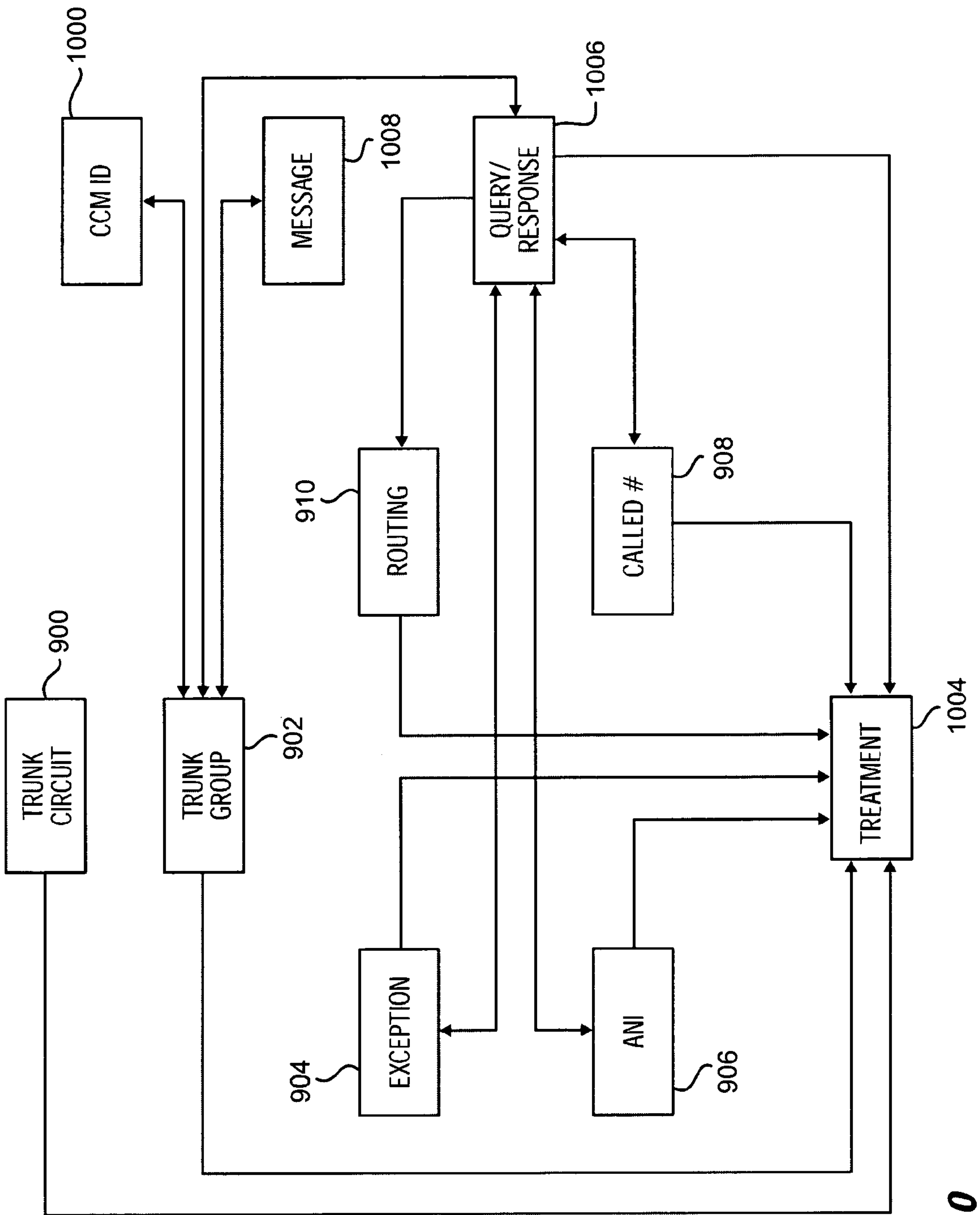
EXCEPTION
906
ANI

FIG. 9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1006
ROUTING
910
CALLED #
908
TRUNK CIRCUIT
900
TRUNK GROUP
902
TREATMENT
1004
EXCEPTION
904
ANI
906

FIG. 10

ASSOCIATED POINT CODE	CIC	VP	VC	TRUNK GROUP NUMBER	GROUP MEMBER NUMBER	HARDWARE IDENTIFIER	ECHO CANCELER	ECHO CONTROL	SATELLITE INDICATOR	CIRCUIT STATUS	CIRCUIT STATE	TIME/ DATE

FIG. 11

TRUNK GROUP NUMBER	GLARE RESOLUTION	CONTINUITY CONTROL	CLLI	SATELLITE TRUNK GROUP	SERVICE INDICATOR	ASSOCIATED NPA	SELECTION SEQUENCE	HOP COUNTER	ACC ACTIVE	OMI	NEXT FUNCTION	INDEX

FIG. 12

EXCEPTION TABLE INDEX	CARRIER SELECTION IDENTIFICATION	CARRIER IDENTIFICATION	CALLED PARTY			NEXT FUNCTION	INDEX
			NATURE OF ADDRESS	DIGITS FROM	DIGITS TO		

FIG. 13

ANI TABLE INDEX	CALLING PARTY CATEGORY	NATURE OF ADDRESS	CALLING PARTY/CHARGE NUMBER			ORIGINATING LINE INFORMATION	NEXT FUNCTION	NEXT INDEX
			DIGITS FROM	DIGITS TO	DATA			

FIG. 14

CALLED NUMBER TABLE INDEX	NATURE OF ADDRESS	DIGITS FROM	DIGITS TO	NEXT FUNCTION	NEXT INDEX

FIG. 15

ROUTING TABLE INDEX	TRANSIT NETWORK SELECTION			CIRCUIT CODE	NEXT FUNCTION #1	INDEX #1	NEXT FUNCTION #2	INDEX #2	NEXT FUNCTION #3	INDEX #3
	NETWORK IDENTIFICATION PLAN	DIGITS FROM	DIGITS TO							

FIG. 16

INDEX	MESSAGE RECEIVED CAUSE VALUE	GENERAL LOCATION	CODING STANDARD	CAUSE VALUE	NEXT FUNCTION	INDEX

FIG. 17

MESSAGE TYPE	PARAMETERS	INDEX #1	INDEX #...	INDEX #N
ADDRESS COMPLETE	BACKWARD CALL INDICATOR			
	ACCESS TRANSPORT			
	CAUSE INDICATOR			
	OPTIONAL BACKWARD CALL INDICATORS			
	OPTIONAL "FE" INDICATOR			
ANSWER	ACCESS TRANSPORT			
	BACKWARD CALL INDICATOR			
CALL PROGRESS	EVENT INFORMATION			
	BACKWARD CALL INDICATOR			
	ACCESS TRANSPORT			
	CAUSE INDICATOR			
	OPTIONAL BACKWARD CALL INDICATOR			
CIRCUIT RESERVATION	NATURE OF CONNECTION INDICATOR			
CIRCUIT RESERVATION ACK	N/A			
CONFUSION	N/A			
CONTINUITY	CONTINUITY INDICATOR			
EXIT	OUTGOING TRUNK GROUP NUMBER			
INFORMATION	ALL PARAMETERS			
INFORMATION REQUEST	ALL PARAMETERS			
INITIAL ADDRESS	NATURE OF CONNECTION INDICATOR			
	FORWARD CALL INDICATOR			
	CALLING PARTY'S CATEGORY			
	USER SERVICE INFORMATION			
	CALLED PARTY NUMBER			
	ACCESS TRANSPORT			
	CALLING PARTY NUMBER			
	CARRIER IDENTIFICATION			
	CARRIER SELECTION INFORMATION			
	CHARGE NUMBER			
	GENERIC ADDRESS			
	ORIGINATING LINE INFORMATION			
	ORIGINAL CALLED NUMBER			
	REDIRECTING NUMBER			
	SERVICE CODE			
	TRANSIT NETWORK SELECTION			
	HOP COUNTER			
PASS ALONG	ALL PARAMETERS			
RELEASE	CAUSE INDICATOR			
	ACCESS TRANSPORT			
	AUTOMATIC CONGESTION CONTROL			
RELEASE COMPLETE	N/A			
RESUME	SUSPEND/RESUME INDICATOR			
SUSPEND	SUSPEND/RESUME INDICATOR			

FIG. 18

NUMBER PORTABILITY IN A COMMUNICATIONS SYSTEM

RELATED APPLICATIONS

This application is a continuation of application Ser. No. 10/077,544 filed on Feb. 15, 2000, now U.S. Pat. No. 6,639,912, which is a continuation of application Ser. No. 09/272,131 filed on Mar. 19, 1999, now U.S. Pat. No. 6,795,440, which is a continuation of application Ser. No. 08/755,268 filed on Nov. 22, 1996, now U.S. Pat. No. 6,014,378, filed on Nov. 22, 1996. U.S. Pat. Nos. 6,639,912, 6,795,440, and 6,014,378 are hereby incorporated by reference into this application.

FEDERALLY SPONSERED RESEARCH OR DEVELOPMENT

Not applicable

MICROFICHE APPENDIX

Not applicable

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to tandem systems for circuit-based traffic, and in particular, to tandem systems that use Asynchronous Transfer Mode (ATM) systems to interconnect various circuit-based networks or network elements.

2. Description of the Prior Art

The tandem function is used to concentrate and switch telecommunications traffic in between networks, switches, and other network elements. FIG. **1** depicts the conventional tandem switch known in the prior art. The three switches and the network element are all connected to the tandem switch. The tandem switch allows the switches to connect to the network element without a direct connection between the switches and the network element. It also allows each switch to connect to every other switch without direct connections between all of the switches. This savings in connections and trunking is one of the benefits of tandem switches. Additionally, the connection between the tandem switch and the network element uses bandwidth more efficiently because traffic has been concentrated at the tandem switch. In addition, a tandem switch can be used to concentrate traffic that is going to other networks.

The connections shown on FIG. **1** as solid lines are circuit-based connections. Circuit-based connections are well known in the art with some examples being Time Division Multiplex (TDM) connections, such as DS3, DS1, DS0, E3, E1, or E0 connections. DS3 connections carry a continuous transport signal at 44.736 megabits per second. DS1 connections carry a continuous transport signal at 1.544 megabits per second. DS0 connections carry a continuous transport signal at 64 kilobits per second. As is known, DS3 connections can be comprised of multiple DS1 connections, which in turn, can be comprised of multiple DS0 connections. The signaling links shown as dashed lines may be conventional signaling links with examples being SS7, C7, or ISDN links. The switches shown on FIG. **1** are well known circuit switches with examples being the Nortel DMS-250 or the Lucent 5ESS. The tandem switch is typically comprised of a circuit switch that interconnects DS3, DS1, and DS0 connections.

Those skilled in the art are aware of the costs and efficiencies associated with tandem switches. Many networks cannot justify implementing a tandem switch until the efficiencies gained through the tandem function outweigh the cost of the tandem switch. This is problematic because inefficiencies must be tolerated until they outweigh the high cost of the tandem switch. At present, there is a need for a more affordable and efficient tandem switching system.

SUMMARY

The invention includes a telecommunications tandem system and method for providing a tandem connection for a call. The tandem system comprises a first ATM interworking multiplexer, an ATM cross-connect, a second ATM interworking multiplexer, and a signaling processor. The first ATM interworking multiplexer receives circuit-based traffic for the call from a first circuit-based connection. It converts the circuit-based traffic into ATM cells that identify a selected virtual connection based on a first control message and transmits the ATM cells. The ATM cross-connect is connected to the first ATM interworking multiplexer. It receives the ATM cells from the first ATM interworking multiplexer and routes the ATM cells based on the selected virtual connection identified in the ATM cells. The second ATM interworking multiplexer that is connected to the ATM cross-connect. It receives the ATM cells from the ATM cross-connect. It converts the ATM cells into the circuit-based traffic and transmits the circuit-based traffic over a selected second circuit-based connection based on a second control message. The signaling processor is linked to the first ATM multiplexer and the second ATM multiplexer. It receives and processes telecommunications signaling for the call to select the virtual connection and the second circuit-based connection. It provides the first control message for the call to the first ATM multiplexer and provides the second control message for the call to the second ATM multiplexer. The first control message identifies the first circuit-based connection and the selected virtual connection. The second control message identifies the selected virtual connection and the selected second circuit-based connection. As a result, the tandem connection is formed by the first circuit based connection, the selected virtual connection, and the selected second circuit based connection.

In various other embodiments. The tandem system provides the tandem connection for the call between: two circuit-based switches, two circuit-based switching networks, a circuit-based switch and an enhanced services platform, an incumbent local exchange carrier and a competitive local exchange carrier, a first competitive local exchange carrier and a second competitive local exchange carrier, a local exchange carrier and an interexchange carrier, for the call, a local exchange carrier and an international carrier, an interexchange carrier and an international carrier.

In various embodiments, the signaling processor selects the connections for the call based on: a call set-up message, a Signaling System #7 Initial Address Message (SS7 IAM), a called number, an NPA, an NXX, an NPA-NXX, a destination network, a transit network selection code, a carrier identification parameter, a nature of address, a network element identifier, a local route number, or a trunk group.

In various embodiments, numerous physical limitations may also distinguish the invention. The first ATM multiplexer and the second ATM multiplexer may be incorporated into a single ATM multiplexer. The first control message and the second control message may be incorporated into a single control message. The first ATM multiplexer, the

second ATM multiplexer, and the ATM cross-connect may be physically located at the same site. The signaling processor, the first ATM multiplexer, the second ATM multiplexer, and the ATM cross-connect may be physically located at the same site.

Advantageously, the invention provides a tandem function between circuit based systems without the need for a circuit-based switch or an ATM switch. The invention is capable of accomplishing various forms of tandem routing without requiring a full set of complex routing logic. For example, the invention may only analyze a destination network code to select a tandem connection and could omit the need to analyze a called number. The invention is also capable of providing an ATM interface.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of a version of the prior art.

FIG. **2** is a block diagram of a version of the present invention.

FIG. **3** is a block diagram of a version of the present invention.

FIG. **4** is a block diagram of a version of the present invention.

FIG. **5** is a logic diagram of a version of the present invention.

FIG. **6** is a logic diagram of a version of the invention.

FIG. **7** is a message sequence chart of a version of the invention.

FIG. **8** is a block diagram of a version of the present invention.

FIG. **9** is a logic diagram of a version of the present invention.

FIG. **10** is a logic diagram of a version of the present invention.

FIG. **11** depicts an example of the trunk circuit table.

FIG. **12** depicts an example of the trunk group table.

FIG. **13** depicts an example of the exception table.

FIG. **14** depicts an example of the ANI table.

FIG. **15** depicts an example of the called number table.

FIG. **16** depicts an example of the routing table.

FIG. **17** depicts an example of the treatment table.

FIG. **18** depicts an example of the message table.

DETAILED DESCRIPTION

For purposes of clarity, the term "connection" will be used to refer to the transmission media used to carry user traffic. The term "link" will be used to refer to the transmission media used to carry signaling or control messages. FIG. **1** depicts a prior art tandem switch. Shown are three switches connected to a network element through the tandem switch. The switches are also connected to each other through the tandem switch. The use of the tandem switch avoids the need for direct connections between all of these switches and the network element. The use of the tandem switch also avoids the need for direct connections between the switches themselves. Typically, the tandem switch is comprised of a conventional circuit switch.

FIG. **2** depicts a version of the present invention. Shown is tandem system **200**, switch **210**, switch **212**, switch **214**, and network element **290**. Switches **210**, **212**, and **214** are connected to tandem system **200** by connections **220**, **222**, and **224** respectively. Switches **210**, **212**, and **214** are linked to tandem system **200** by links **230**, **232**, and **234** respectively. As stated above, the "connections" carry telecommunications traffic and the "links" carry telecommunications signaling and control messages. Tandem system **200** is also connected and linked to network element **290** by connection **226** and link **236**.

Those skilled in the art are aware that large networks have many more components than are shown. For example, there would typically be a multitude of switches and network elements connected through tandem system **200**. Those skilled in the art will appreciate that a signal transfer point (STP) could be used to transfer signaling among the various components. The number of components shown on FIG. **2** has been restricted for clarity. The invention is fully applicable to a large network.

Switches **210**, **212**, and **214** could be conventional circuit switches or any source of circuit-based traffic. Network element **290** represents any element that accepts circuit-based traffic. Examples of such network elements are switches and enhanced service platforms. Often, network element **290** would be in a different telecommunications network than switches **210**, **212**, and **214**. Connections **220**, **222**, **224**, and **226** could be any connection that carries circuit-based traffic. Typically, these are DS3 or DS1 connections. Typically, the common DS0 used for traditional voice calls is embedded within the DS3 or DS1. Links **230**, **232**, **234**, and **236** are any links that carry telecommunications signaling or control messages with an example being a Signaling System #7 (SS7) link. Those skilled in the art are familiar with circuit-based traffic and signaling.

Tandem system **200** is a set of components that are operational to accept circuit-based traffic and signaling, and then switch the traffic to the proper destination in accord with the signaling. An example would be where switch **210** handles a call destined for network element **290**. Switch **210** would seize a call connection within connection **220** to tandem system **200**. Typically, this call connection is a DS0 embedded within a DS3. Additionally, switch **210** will forward an SS7 Initial Address Message (IAM) to tandem system **200** over link **230**. An IAM contains information such as the dialed number, the caller's number, and the circuit identification code (CIC). The CIC identifies the incoming DS0 in connection **220** that is used for the call. Tandem system **200** will receive and process the IAM and select an outgoing connection for the call. In this example, this would be a DS0 embedded within connection **226** to network element **290**. As a result, tandem system **200** will connect the DS0 in connection **220** to the selected DS0 in connection **226**. Additionally, tandem system **200** may forward an IAM or other message to network element **290** over link **236**. The same basic procedure could be used to connect a call from switch **214** to switch **212**, or to connect a call from network element **290** to switch **214**.

Tandem system **200** operates using the following technique. Tandem system **200** converts the incoming circuit-based traffic into Asynchronous Transfer Mode (ATM) cells. It also processes the incoming signaling associated with the traffic to select appropriate ATM connections for the cells. It then routes the cells through an ATM matrix. After leaving the matrix, the ATM cells are converted back into a circuit-based format and provided to a selected circuit-based connection. By controlling the selections of the ATM connection and circuit-based connection, tandem system **200** is able to connect any inbound circuit-based connection to any outbound circuit-based connection. For example, any incoming DS0 could be connected to any outbound DS0 by selecting the appropriate ATM virtual channel and outbound DS0 within the tandem system. It should be pointed out that the use of ATM can be completely internal to tandem system **200** and can be transparent to the external network outside

of tandem system **200**. In some embodiments, tandem system **200** could also receive and transmit ATM traffic in addition to circuit-based traffic.

FIG. **3** depicts tandem system **300** which is a version of the tandem system from FIG. **2**. Those skilled in the art will appreciate variations from this version that are also contemplated by the invention. Tandem system **300** has connections **320**, **322**, **324**, and **326** that correspond to connections **220**, **222**, **224**, and **226** of FIG. **2**. Tandem system **300** has links **330**, **332**, **334**, and **336** that correspond to links **230**, **232**, **234**, and **236** of FIG. **2**.

Tandem system **300** is comprised of signaling processor **350**, ATM interworking multiplexer (mux) **360**, mux **362**, mux **364**, and ATM cross-connect **370**. Mux **360** is connected to cross-connect **370** by connection **380**. Mux **362** is connected to cross-connect **370** by connection **382**. Mux **364** is connected to cross-connect **370** by connection **384**. Muxes **360**, **362**, and **364** are linked to signaling processor **350** by link **390**.

Connections **380**, **382**, and **384** could be any connections that support ATM. Link **390** could be any link capable of transporting control messages. Examples of such a link could be SS7 links, UDP/IP or TCP/IP over Ethernet, or a bus arrangement using a conventional bus protocol.

Signaling processor **350** is any processing platform that can receive and process signaling to select virtual connections and circuit-based connections, and then generate and transmit messages to identify the selections. Various forms of signaling are contemplated by the invention, including ISDN, SS7, and C7. A preferred embodiment of the signaling processor is discussed in detail toward the end of the disclosure.

Muxes **360**, **362**, and **364** could be any system operable to interwork traffic between ATM and non-ATM formats in accord with control messages from signaling processor **350**. These control messages are typically provided on a call-by-call basis and identify an assignment of a DS0 to a Virtual Path Identifiers/Virtual Channel Identifier (VPI/VCI). The mux would interwork the user traffic between the DS0 and ATM based on the control messages. For example, a mux might receive a DS0 call connection and convert this traffic into ATM cells with a VPI/VCI selected by signaling processor. A mux may also receive ATM cells from ATM cross-connect **370**. These ATM cells would be converted back into the DS0 format and provided to the DS0 call connection selected by signaling processor **350**. In some embodiments, the muxes are operational to implement digital signal processing as instructed in control messages (typically from signaling processor **350**). An example of digital signal processing would be echo cancellation or continuity testing. A preferred embodiment of these muxes are also discussed in detail below.

ATM cross-connect **370** is any device that provides a plurality of ATM virtual connections between the muxes. An example of an ATM cross-connect is the NEC Model 20. In ATM, virtual connections can be designated by the VPI/VCI in the cell header. Cross-connect **370** can be configured to provide a plurality of VPI/VCI connections between the muxes. The following examples illustrate a possible configuration. VPI "A" could be provisioned from mux **360** through cross-connect **370** to mux **362**. VPI "B" could be provisioned from mux **360** through cross-connect **370** and to mux **364**. VPI "C" could be provisioned from mux **360** through cross-connect **370** and back to mux **360**. Similarly, VPIs could be provisioned from: mux **362** to mux **360**, mux **362** to mux **364**, mux **362** back to mux **362**, mux **364** to mux **360**, mux **364** to mux **362**, and mux **364** back to mux **364**.

In this way, the selection of the VPI essentially selects the outgoing mux. The VCIs could be used to differentiate individual calls on the VPI between two muxes.

DS3, DS1, and DS0 connections are bi-directional, whereas ATM connections are unidirectional. This means that the bi-directional connections will typically require two ATM connections—one in each direction. This could be accomplished by assigning a companion VPI/VCI to each VPI/VCI used for call set-up. The muxes would be configured to invoke the companion VPI/VCI in order to provide a return path for the bi-directional connection.

In some embodiments, the signaling processor, the muxes, and the cross-connect will all be physically located at the same site. For example, the tandem system would occupy a single site just as a circuit switch occupies a single site. In this way, the tandem system physically and functionally emulates a tandem circuit switch. However, the component nature of the tandem system allows it to be distributed if desired. For example, in alternative embodiments, the muxes and the cross-connect will be physically located at the same site, but the signaling processor will be located at a remote site.

The system would operate as follows for a call on connection **320** destined for connection **326**. In this embodiment, the user information from connection **324** is capable of being muxed to the DS0 level, but this is not required in other embodiments. Additionally, SS7 signaling is used in this embodiment, but other signaling protocols, such as C7 signaling, are also applicable to the invention.

A DS0 in connection **320** would be seized and an IAM related to the call would be received over link **330**. Signaling processor **350** would process the IAM to select a VPI/VCI from mux **362** through ATM cross-connect **370** to mux **364**. Signaling processor **350** would also select a DS0 on connection **326** from mux **364**. These selections may be based on many factors with a few examples being the dialed number or the identity of the destination network. Signaling processor **350** would send a control message over link **390** to mux **362** that identifies both the seized DS0 in connection **320** and the selected VPI/VCI. Signaling processor **350** would also send a control message over link **390** to mux **364** that identifies both the selected VPI/VCI and the selected DS0 in connection **326**. If required, signaling processor **350** would also instruct one of the muxes to apply echo cancellation to the call. In addition, signaling processor **350** would transmit any signaling required to continue call set-up over links **330** and **336**.

Mux **362** would receive the control message from signaling processor **350** identifying the seized DS0 in connection **320** and the selected VPI/VCI. Mux **362** would then convert the user information from the seized DS0 in connection **320** into ATM cells. Mux **362** would designate the selected VPI/VCI in the cell headers.

The virtual connection designated by the selected VPI/VCI would have been previously provisioned through cross-connect **370** from mux **362** to mux **364**. As a result, cells with the selected VPI/VCI are transmitted over connection **382** and transferred by cross-connect **370** over connection **384** to mux **364**.

Mux **364** would receive a control message from signaling processor **350** identifying the selected VPI/VCI and the selected DS0 in connection **326**. Mux **364** will convert the ATM cells with the selected VPI/VCI in the cell header to the selected DS0 on connection **326**. Thus it can be seen that the selections of the VPI/VCI and DS0 by signaling processor **350** can be implemented by muxes **362** and **364** to

interconnect DS0s on connection **320** and **326**. These interconnections can be provided by tandem system **300** on a call by call basis.

Upon completion of the call, signaling processor **350** would receive a release message (REL) indicating call tear-down. As a result, signaling processor **350** would provide tear down messages to mux **360** and mux **364**. When the muxes receive these messages they would disassociate the VPI/VCI and the DS0s. This effectively terminates the call connection and frees up the VPI/VCI and DS0s for use on other calls.

From the above description, it can be seen that call-by-call control over the VPI/VCIs and DS0s at the ATM/DS0 interworking point is used to interconnect the traffic from incoming DS0s to outbound DS0s. This interworking point where traffic is converted is in the muxes. Unlike conventional circuit switches, the matrix (i.e. the cross-connect) is not controlled on a call-by-call basis. It is merely provisioned to interconnect the muxes. This greatly simplifies the invention over conventional tandem switches. This unique combination of components and control provides many advantages for a tandem system. It can typically be produced at lower costs than a conventional tandem circuit switch. The components of the tandem system are readily scaleable, so that the size of the tandem system can be tailored to specific traffic demands and upgraded as needed. As will be seen, the signaling processor is not integrated within a switch. This allows it to be tailored more readily to a given task. For example, robust and expensive routing logic may not be required.

FIG. **4** depicts tandem system **400**. Tandem system **400** is the same as tandem system **300** from FIG. **3**, except that connection **486** has been added. For the purposes of clarity, the other reference numbers have been omitted. Connection **486** is ATM connection. Typically, the ATM connection would use a transport protocol, such as SONET or DS3, but others are also known. Connection **486** provides ATM systems with access to tandem system **400**. This access occurs through the cross-connect. The cross-connect would be provisioned to connect particular VPI/VCIs on connection **486** to particular muxes. In this way, non-ATM traffic entering tandem system **400** through a mux could egress the system in the ATM format over connection **486**. Additionally, ATM traffic could enter tandem system **400** over connection **486** and egress through a mux on a non-ATM connection. In some embodiments, a signaling link from the signaling processor to the cross-connect could be used to exchange B-ISDN signaling between the signaling processor and the ATM system through the cross-connect and connection **486**. In such an embodiment, B-ISDN signaling VPI/VCIs are provisioned through the cross-connect between the signaling processor and the ATM system. Advantageously, tandem system **400** provides tandem access to and from ATM systems.

FIG. **5** depicts tandem system **500**, switch **510**, switch **512**, network element **514**, network **520**, network **522**, and network **524**. These components are all known in the art and are connected and linked as shown on FIG. **5**. These connections and links are as described above, but for the sake of clarity, the connections and links are not numbered. Tandem system **500** operates as described above.

FIG. **5** is provided to illustrate various routing features of tandem system **500**. Because tandem system **500** may be implemented to provide a specific type of tandem function, the routing can be tailored to the specific needs as well. Advantageously, this can simplify the complexity and cost of tandem system **500**.

In one embodiment, tandem system **500** routes based on the area code (NPA) in a dialed number. This could be the case where switches **510** and **512** provide traffic to tandem system **500** for routing to network element **514** and networks **520**, **522**, and **524**. If the network element and networks can be differentiated for purposes of routing by area code, then tandem system **500** need not be configured with complex routing logic.

In one embodiment, tandem system **500** routes based on the exchange code (NXX) in a dialed number. This might be the case where switches **510** and **512**, network element **514**, and networks **520**, **522**, and **524** are all in the same area code. If these components are in the same area code, but can be differentiated for purposes of routing by NXX, then tandem system **500** need not be configured with complex routing logic. In another embodiment, tandem system **500** could route based on both NPA and NXX.

In some embodiments, tandem system **500** could route based on the identity of the destination network. Often, the identity of the next network in the call path is provided in a signaling message. Tandem system **500** would receive the signaling message over a signaling link an identify the destination network. The SS7 IAM includes a transit network selection code or a carrier identification parameter. Either of these codes can be used by tandem system **500** to identify the destination network and select a route to the destination network. For example, switch **512** may identify network **524** as the destination network in the IAM to tandem system **500**. By reading the carrier identification parameter in the IAM, tandem system **500** could identify network **524** as the destination and select a route to network **524**. This eliminates significant call processing and simplifies tandem system **500**.

In some embodiments, tandem system **500** could read the nature of address in the IAM to identify types of operator assisted and international calls. Once identified, the calls could be routed to the appropriate operator system or international carrier.

In some embodiments, the tandem system **500** may facilitate routing in a number portability scenario. Number portability allows called parties to retain their telephone number when they move. When a network encounters one of these ported numbers, it will launch a TCAP query to a database that can identify the new network element that now serves the called party. (Typically, this new network element is the class **5** switch where the called party is now located.) The identity of the network element is provided in a TCAP response back to the network element that sent the query. The TCAP response identifies the new network element that now serves the called party. This identification can be a local route number contained in the TCAP.

In the context of the invention, tandem system **500** could support number portability. Tandem system **500** could query the database and route to the appropriate network based on the local route number in the TCAP response. Tandem system **500** could also receive calls from systems that have already queried the number portability database. In this case, tandem system **500** would use the local route number in the signaling to identify the destination network and route the call.

In some embodiments, the key to routing the call will be trunk group selection. Trunk groups typically contain many DS0s. For example, the connections between tandem system **500** and networks **520**, **522**, and **524** could each be a trunk group. For calls received from switches **510** and **512**, tandem system **500** may only need to determine which of these three trunk groups to use. This is because the selection

of the trunk group effectively routes the call to the proper network. The selection of the DS0 within the selected trunk group is based on the availability within the selected trunk group.

FIG. **6** depicts tandem system **600**, Incumbent Local Exchange Carrier (ILEC) **620**, Competitive Local Exchange Carrier (CLEC) **622**, CLEC **624**, Interexchange Carrier (IXC) **626**, IXC **628**, and international carrier **630**. These networks are familiar to those skilled in the art and are connected and linked as shown. Examples of the connections are DS1, DS3 or ATM connections and examples of the links are SS7 links, although other connections and links that apply are also known. ILECs are the established local networks. The CLECs are newer local networks that are allowed to compete with the established local networks. As a result, numerous LECs—either incumbent or competitive—will provide services to the same area. These ILECs and CLECs will need access to each other. They will also need access to IXCs for long distance calls and to international carriers for international calls. Tandem system **600** is similar to the tandem systems described above and it provides interconnection among these networks. For example, all local calls from ILEC **620** to CLEC **622** may use tandem system **600** for the interconnection. Call signaling and connections would be provided to tandem system **600** by ILEC **620**. Tandem system would process the signaling and interconnect the calls to CLEC **622**. Tandem system **600** would typically send additional signaling to CLEC **622** to facilitate call completion.

Similar arrangements could be made between the other networks. Tandem system **600** could provide tandem access between the following combinations: CLEC and CLEC, CLEC and ILEC, ILEC and IXC, CLEC and IXC, IXC and IXC, ILEC and international carrier, CLEC and international carrier, and IXC and international carrier. In some cases this routing could be effected by processing the local routing number, transit network selection code, or carrier identification parameter. In this way, call processing at tandem system **600** is simplified, yet each network has access to the other networks without managing multiple connections.

The ATM Interworking Multiplexer

FIG. **7** shows one embodiment of the mux that is suitable for the present invention, but other muxes that support the requirements of the invention are also applicable. Shown are control interface **700**, OC-3 interface **705**, DS3 interface **710**, DS1 interface **715**, DS0 interface **720**, digital signal processor **325**, ATM adaption Layer (AAL) **730**, and OC-3 interface **735**.

Control interface **700** accepts messages from the signaling processor. In particular, control interface **700** provides DS0/virtual connection assignments to AAL **730** for implementation. Control interface **700** may accept control messages from the signaling processor with messages for DS0 **720**. These messages could be to connect DS0s to: 1) other DS0s, 2) digital signal processor **725**, or 3) AAL **730** (bypassing digital signal processor **725**). Control interface **700** may accept control messages from the signaling processor with messages for digital signal processing **725**. An example of such an message would be to disable an echo canceller on a particular connection.

OC-3 interface **705** accepts the OC-3 format and makes the conversion to DS3. DS3 interface **710** accepts the DS3 format and makes the conversion to DS1. DS3 interface **710** can accept DS3s from OC-3 interface **705** or from an external connection. DS1 interface **715** accepts the DS1 format and makes the conversion to DS0. DS1 interface **715** can accept DS1s from DS3 interface **710** or from an external connection. DS0 interface **720** accepts the DS0 format and provides an interface to digital signal processor **725** or AAL **730**. In some embodiments, DS0 interface **420** could be capable of directly interconnecting particular DS0s. This could be the case for call entering and egressing from the same mux. This would also be useful to facilitate continuity testing by a switch. OC-3 interface **735** is operational to accept ATM cells from AAL **730** and transmit them, typically over the connection to a cross-connect.

Digital signal processor **725** is operational to apply various digital processes to particular DS0s in response to control messages received through control interface **700**. Examples of digital processing include: tone detection, tone transmission, loopbacks, voice detection, voice messaging, echo cancellation, compression, and encryption. In some embodiments, digital signal processing **725** could handle continuity testing. For example, the signaling processor may instruct the mux to provide a loopback for a continuity test and or disable cancellation for a call. Digital signal processor **725** is connected to AAL **730**. As discussed, DS0s from DS0 interface **720** may bypass digital signal processing **725** and be directly coupled to AAL **730**.

AAL **730** comprises both a convergence sublayer and a segmentation and reassembly (SAR) layer. AAL **730** is operational to accept the user information in DS0 format from DS0 interface **720** or digital signal processor **725** and convert the information into ATM cells. AALs are known in the art and information about AALs is provided by International Telecommunications Union (ITU) document 1.363. An AAL for voice is also described in U.S. patent application Ser. No. 08/395,745, filed on Feb. 28, 1995, entitled "Cell Processing for Voice Transmission", and hereby incorporated by reference into this application. AAL **730** obtains the virtual path identifier (VPI) and virtual channel identifier (VCI) for each call from control interface **700**. AAL **730** also obtains the identity of the DS0 for each call (or the DS0s for an N×64 call). AAL **730** then converts user information between the identified DS0 and the identified ATM virtual connection. Acknowledgments that the assignments have been implemented may be sent back to the signaling processor if desired. Calls with a bit rate that are a multiple of 64 kbit/second are known as N×64 calls. If desired, AAL **730** can be capable of accepting control messages through control interface **700** for N×64 calls.

As discussed above, the mux also handles calls in the opposite direction—from OC-3 interface **735** to DS0 interface **720**. This traffic would have been converted to ATM by another mux and routed to OC-3 **735** by the cross-connect over the selected VPI/VCI. Control interface **700** will provide AAL **730** with the assignment of the selected VPI/VCI to the selected outbound DS0. The mux will convert the ATM cells with the selected VPI/VCI in the cell headers into the DS0 format and provide it to the selected outbound DS0 connection.

A technique for processing VPI/VCIs is disclosed in U.S. Pat. No. 5,940,393, which is hereby incorporated by reference into this application.

DS0 connections are bi-directional and ATM connections are typically unidirectional. As a result, two virtual connections in opposing directions will typically be required for each DS0. As discussed, this can be accomplished provisioning the cross-connect with companion VPI/VCIs in the opposite direction as the original VPI/VCIs. On each call, the muxes would be configured to automatically invoke the

particular companion VPI/VCI to provide a bidirectional virtual connection to match the bi-directional DS0 on the call.

The Signaling Processor

The signaling processor is referred to as a call/connection manager (CCM), and it receives and processes telecommunications call signaling and control messages to select connections that establish communication paths for calls. In the preferred embodiment, the CCM processes SS7 signaling to select connections for a call. CCM processing is described in U.S. Pat. No. 6,013,840 which is assigned to the same assignee as this patent application, and which is incorporated herein by reference.

In addition to selecting connections, the CCM performs many other functions in the context of call processing. It not only can control routing and select the actual connections, but it can also validate callers, control echo cancellers, generate billing information, invoke intelligent network functions, access remote databases, manage traffic, and balance network loads. One skilled in the art will appreciate how the CCM described below can be adapted to operate in the above embodiments.

FIG. **8** depicts a version of the CCM. Other versions are also contemplated. In the embodiment of FIG. **8**, CCM **800** controls an ATM interworking multiplexer (mux) that performs interworking of DS0s and VPI/VCIs. However, the CCM may control other communications devices and connections in other embodiments.

CCM **800** comprises signaling platform **810**, control platform **820**, and application platform **830**. Each of the platforms **810**, **820**, and **830** is coupled to the other platforms.

Signaling platform **810** is externally coupled to the SS7 systems—in particular to systems having a message transfer part (MTP), an ISDN user part (ISUP), a signaling connection control part (SCCP), an intelligent network application part (INAP), and a transaction capabilities application part (TCAP). Control platform **820** is externally coupled to a mux control, an echo control, a resource control, billing, and operations.

Signaling platform **810** comprises MTP levels **1**–**3**, ISUP, TCAP, SCCP, and INAP functionality and is operational to transmit and receive the SS7 messages. The ISUP, SCCP, INAP, and TCAP functionality use MTP to transmit and receive the SS7 messages. Together, this functionality is referred as an "SS7 stack," and it is well known. The software required by one skilled in the art to configure an SS7 stack is commercially available, for example, from the Trillium company.

Control platform **820** is comprised of various external interfaces including a mux interface, an echo interface, a resource control interface, a billing interface, and an operations interface. The mux interface exchanges messages with at least one mux. These messages comprise DS0 to VPI/VCI assignments, acknowledgments, and status information. The echo control interface exchanges messages with echo control systems. Messages exchanged with echo control systems might include instructions to enable or disable echo cancellation on particular DS0s, acknowledgments, and status information.

The resource control interface exchanges messages with external resources. Examples of such resources are devices that implement continuity testing, encryption, compression, tone detection/transmission, voice detection, and voice messaging. The messages exchanged with resources are instructions to apply the resource to particular DS0s, acknowledgments, and status information. For example, a message may instruct a continuity testing resource to provide a loop back or to send and detect a tone for a continuity test.

The billing interface transfers pertinent billing information to a billing system. Typical billing information includes the parties to the call, time points for the call, and any special features applied to the call. The operations interface allows for the configuration and control of CCM **800**. One skilled in the art will appreciate how to produce the software for the interfaces in control platform **820**.

Application platform **830** is functional to process signaling information from signaling platform **810** in order to select connections. The identity of the selected connections are provided to control platform **820** for the mux interface. Application platform **830** is responsible for validation, translation, routing, call control, exceptions, screening, and error handling. In addition to providing the control requirements for the mux, application platform **830** also provides requirements for echo control and resource control to the appropriate interface of control platform **820**. In addition, application platform **830** generates signaling information for transmission by signaling platform **810**. The signaling information might be ISUP, INAP, or TCAP messages to external network elements. Pertinent information for each call is stored in a call control block (CCB) for the call. The CCB can be used for tracking and billing the call.

Application platform **830** operates in general accord with the Basic Call Model (BCM) defined by the ITU. An instance of the BCM is created to handle each call. The BCM includes an originating process and a terminating process. Application platform **830** includes a service switching function (SSF) that is used to invoke the service control function (SCF). Typically, the SCF is contained in a service control point (SCP). The SCF is queried with TCAP or INAP messages. The originating or terminating processes will access remote databases with intelligent network (IN) functionality via the SSF function.

Software requirements for application platform **830** can be produced in specification and description language (SDL) defined in ITU-T Z.100. The SDL can be converted into C code. Additional C and C++ code can be added as required to establish the environment.

CCM **800** can be comprised of the above-described software loaded onto a computer. The computer can be an Integrated Micro Products (IMP) FT-Sparc 600 using the Solaris operating system and conventional database systems. It may be desirable to utilize the multi-threading capability of a Unix operating system.

From FIG. **8**, it can be seen that application platform **830** processes signaling information to control numerous systems and facilitate call connections and services. The SS7 signaling is exchanged with external components through signaling platform **810**, and control information is exchanged with external systems through control platform **820**. Advantageously, CCM **800** is not integrated into a switch CPU that is coupled to a switching matrix. Unlike an SCP, CCM **800** is capable of processing ISUP messages independently of TCAP queries.

SS7 Message Designations

SS7 messages are well known. Designations for various SS7 messages commonly are used. Those skilled in the art are familiar with the following message designations:

ACM	Address Complete Message
ANM	Answer Message
BLO	Blocking
BLA	Blocking Acknowledgment
CPG	Call Progress
CRG	Charge Information
CGB	Circuit Group Blocking
CGBA	Circuit Group Blocking Acknowledgment
GRS	Circuit Group Reset
GRA	Circuit Group Reset Acknowledgment
CGU	Circuit Group Unblocking
CGUA	Circuit Group Unblocking Acknowledgment
CQM	Circuit Group Query
CQR	Circuit Group Query Response
CRM	Circuit Reservation Message
CRA	Circuit Reservation Acknowledgment
CVT	Circuit Validation Test
CVR	Circuit Validation Response
CFN	Confusion
COT	Continuity
CCR	Continuity Check Request
EXM	Exit Message
INF	Information
INR	Information Request
JAM	Initial Address
LPA	Loop Back Acknowledgment
PAM	Pass Along
REL	Release
RLC	Release Complete
RSC	Reset Circuit
RES	Resume
SUS	Suspend
UBL	Unblocking
UBA	Unblocking Acknowledgment
UCIC	Unequipped Circuit Identification Code.

CCM Tables

Call processing typically entails two aspects. First, an incoming or "originating" connection is recognized by an originating call process. For example, the initial connection that a call uses to enter a network is the originating connection in that network. Second, an outgoing or "terminating" connection is selected by a terminating call process. For example, the terminating connection is coupled to the originating connection in order to extend the call through the network. These two aspects of call processing are referred to as the originating side of the call and the terminating side of the call.

FIG. **9** depicts a data structure used by application platform **830** to execute the BCM. This is accomplished through a series of tables that point to one another in various ways. The pointers are typically comprised of next function and next index designations. The next function points to the next table, and the next index points to an entry or a range of entries in that table. The data structure has trunk circuit table **900**, trunk group table **902**, exception table **904**, ANI table **906**, called number table **908**, and routing table **910**.

Trunk circuit table **900** contains information related to the connections. Typically, the connections are DS0 or ATM connections. Initially, trunk circuit table **900** is used to retrieve information about the originating connection. Later, the table is used to retrieve information about the terminating connection. When the originating connection is being processed, the trunk group number in trunk circuit table **900** points to the applicable trunk group for the originating connection in trunk group table **902**.

Trunk group table **902** contains information related to the originating and terminating trunk groups. When the originating connection is being processed, trunk group table **902** provides information relevant to the trunk group for the originating connection and typically points to exception table **904**.

Exception table **904** is used to identify various exception conditions related to the call that may influence the routing or other handling of the call. Typically, exception table **904** points to ANI table **906**. Although, exception table **904** may point directly to trunk group table **902**, called number table **908**, or routing table **910**.

ANI table **906** is used to identify any special characteristics related to the caller's number. The caller's number is commonly known as automatic number identification (ANI). ANI table **906** typically points to called number table **908**. Although, ANI table **906** may point directly to trunk group table **902** or routing table **910**.

Called number table **908** is used to identify routing requirements based on the called number. This will be the case for standard telephone calls. Called number table **908** typically points to routing table **910**. Although, it may point to trunk group table **902**.

Routing table **910** has information relating to the routing of the call for the various connections. Routing table **910** is entered from a pointer in either exception table **904**, ANI table **906**, or called number table **908**. Routing table **910** typically points to a trunk group in trunk group table **902**.

When exception table **904**, ANI table **906**, called number table **908**, or routing table **910** point to trunk group table **902**, they effectively select the terminating trunk group. When the terminating connection is being processed, the trunk group number in trunk group table **902** points to the trunk group that contains the applicable terminating connection in trunk circuit table **902**.

The terminating trunk circuit is used to extend the call. The trunk circuit is typically a VPI/VCI or a DS0. Thus it can be seen that by migrating through the tables, a terminating connection can be selected for a call.

FIG. **10** is an overlay of FIG. **9**. The tables from FIG. **9** are present, but for clarity, their pointers have been omitted. FIG. **10** illustrates additional tables that can be accessed from the tables of FIG. **9**. These include CCM ID table **1000**, treatment table **1004**, query/response table **1006**, and message table **1008**.

CCM ID table **1000** contains various CCM SS7 point codes. It can be accessed from trunk group table **902**, and it points back to trunk group table **902**.

Treatment table **1004** identifies various special actions to be taken in the course of call processing. This will typically result in the transmission of a release message (REL) and a cause value. Treatment table **1004** can be accessed from trunk circuit table **900**, trunk group table **902**, exception table **904**, ANI table **906**, called number table **908**, routing table **910**, and query/response table **1006**.

Query/response table **1006** has information used to invoke the SCF. It can be accessed by trunk group table **902**, exception table **904**, ANI table **906**, called number table **908**, and routing table **910**. It points to trunk group table **902**, exception table **904**, ANI table **906**, called number table **908**, routing table **910**, and treatment table **1004**.

Message table **1008** is used to provide instructions for messages from the termination side of the call. It can be accessed by trunk group table **902** and points to trunk group table **902**.

FIGS. **11**–**18** depict examples of the various tables described above. FIG. **11** depicts an example of the trunk circuit table. Initially, the trunk circuit table is used to access information about the originating circuit. Later in the processing, it is used to provide information about the termi-

nating circuit. For originating circuit processing, the associated point code is used to enter the table. This is the point code of the switch or CCM associated with the originating circuit. For terminating circuit processing, the trunk group number is used to enter the table.

The table also contains the circuit identification code (CIC). The CIC identifies the circuit which is typically a DS0 or a VPI/VCI. Thus, the invention is capable of mapping the SS7 CICs to the ATM VPI/VCI. If the circuit is ATM, the virtual path (VP) and the virtual channel (VC) also can be used for identification. The group member number is a numeric code that is used for terminating circuit selection. The hardware identifier identifies the location of the hardware associated with the originating circuit. The echo canceller (EC) identification (ID) entry identifies the echo canceller for the originating circuit.

The remaining fields are dynamic in that they are filled during call processing. The echo control entry is filled based on three fields in signaling messages: the echo suppresser indicator in the IAM or CRM, the echo control device indicator in the ACM or CPM, and the information transfer capability in the IAM. This information is used to determine if echo control is required on the call. The satellite indicator is filled with the satellite indicator in the IAM or CRM. It may be used to reject a call if too many satellites are used. The circuit status indicates if the given circuit is idle, blocked, or not blocked. The circuit state indicates the current state of the circuit, for example, active or transient. The time/date indicates when the idle circuit went idle.

FIG. **12** depicts an example of the trunk group table. During origination processing, the trunk group number from the trunk circuit table is used to key into the trunk table. Glare resolution indicates how a glare situation is to be resolved. Glare is dual seizure of the same circuit. If the glare resolution entry is set to "even/odd," the network element with the higher point code controls the even circuits, and the network element with the lower point code controls the odd circuits. If the glare resolution entry is set to "all," the CCM controls all of the circuits. If the glare resolution entry is set to "none," the CCM yields. The continuity control entry lists the percent of calls requiring continuity tests on the trunk group.

The common language location identifier (CLLI) entry is a Bellcore standardized entry. The satellite trunk group entry indicates that the trunk group uses a satellite. The satellite trunk group entry is used in conjunction with the satellite indicator field described above to determine if the call has used too many satellite connections and, therefore, must be rejected. The service indicator indicates if the incoming message is from a CCM (ATM) or a switch (TDM). The outgoing message index (OMI) points to the message table so that outgoing messages can obtain parameters. The associated number plan area (NPA) entry identifies the area code.

Selection sequence indicates the methodology that will be used to select a connection. The selection sequence field designations tell the trunk group to select circuits based on the following: least idle, most idle, ascending, descending, clockwise, and counterclockwise. The hop counter is decremented from the IAM. If the hop counter is zero, the call is released. Automatic congestion control (ACC) active indicates whether or not congestion control is active. If automatic congestion control is active, the CCM may release the call. During termination processing, the next function and index are used to enter the trunk circuit table.

FIG. **13** depicts an example of the exception table. The index is used as a pointer to enter the table. The carrier selection identification (ID) parameter indicates how the caller reached the network and is used for routing certain types of calls. The following are used for this field: spare or no indication, selected carrier identification code presubscribed and input by the calling party, selected carrier identification code presubscribed and not input by the calling party, selected carrier identification code presubscribed and no indication of input by the calling party, and selected carrier identification code not presubscribed and input by the calling party. The carrier identification (ID) indicates the network that the caller wants to use. This is used to route calls directly to the desired network. The called party number nature of address differentiates between 0+ calls, 1+ calls, test calls, and international calls. For example, international calls might be routed to a pre-selected international carrier.

The called party "digits from" and "digits to" focus further processing unique to a defined range of called numbers. The "digits from" field is a decimal number ranging from 1–15 digits. It can be any length and, if filled with less than 15 digits, is filled with 0s for the remaining digits. The "digits to" field is a decimal number ranging from 1–15 digits. It can be any length and, if filled with less than 15 digits, is filled with 9s for the remaining digits. The next function and next index entries point to the next table which is typically the ANI table.

FIG. **14** depicts an example of the ANI table. The index is used to enter the fields of the table. The calling party category differentiates among types of calling parties, for example, test calls, emergency calls, and ordinary calls. The calling party\charge number entry nature of address indicates how the ANI is to be obtained. The following is the table fill that is used in this field: unknown, unique subscriber numbers, ANI not available or not provided, unique national number, ANI of the called party included, ANI of the called party not included, ANI of the called party includes national number, non-unique subscriber number, non-unique national number, non-unique international number, test line test code, and all other parameter values.

The "digits from" and "digits to" focus further processing unique to ANI within a given range. The data entry indicates if the ANI represents a data device that does not need echo control. Originating line information (OLI) differentiates among ordinary subscriber, multiparty line, ANI failure, station level rating, special operator handling, automatic identified outward dialing, coin or non-coin call using database access, 800/888 service call, coin, prison/inmate service, intercept (blank, trouble, and regular), operator handled call, outward wide area telecommunications service, telecommunications relay service (TRS), cellular services, private paystation, and access for private virtual network types of service. The next function and next index point to the next table which is typically the called number table.

FIG. **15** depicts an example of the called number table. The index is used to enter the table. The called number nature of address entry indicates the type of dialed number, for example, national versus international. The "digits from" and "digits to" entries focus further processing unique to a range of called numbers. The processing follows the processing logic of the "digits from" and "digits to" fields in FIG. **9**. The next function and next index point to the next table which is typically the routing table.

FIG. **16** depicts an example of the routing table. The index is used to enter the table. The transit network selection (TNS) network identification (ID) plan indicates the number of digits to use for the CIC. The transit network selection "digits from" and "digits to" fields define the range of numbers to identify an international carrier. The circuit code indicates the need for an operator on the call. The next function and next index entries in the routing table are used to identify a trunk group. The second and third next function/index entries define alternate routes. The third next function entry can also point back to another set of next functions in

the routing table in order to expand the number of alternate route choices. The only other entries allowed are pointers to the treatment table. If the routing table points to the trunk group table, then the trunk group table typically points to a trunk circuit in the trunk circuit table. The yield from the trunk circuit table is the terminating connection for the call.

It can be seen from FIGS. **11**–**16** that the tables can be configured and relate to one another in such a way that call processes can enter the trunk circuit table for the originating connection and can traverse through the tables by keying on information and using pointers. The yield of the tables is typically a terminating connection identified by the trunk circuit table. In some cases, treatment is specified by the treatment table instead of a connection. If, at any point during the processing, a trunk group can be selected, processing may proceed directly to the trunk group table for terminating circuit selection. For example, it may be desirable to route calls from a particular ANI over a particular set of trunk groups. In this case, the ANI table would point directly to the trunk group table, and the trunk group table would point to the trunk circuit table for a terminating circuit. The default path through the tables is: trunk circuit, trunk group, exception, ANI, called number, routing, trunk group, and trunk circuit.

FIG. **17** depicts an example of the treatment table. Either the index or the message received cause number are filled and are used to enter the table. If the index is filled and used to enter the table, the general location, coding standard, and cause value indicator are used to generate an SS7 REL. The message received cause value entry is the cause value in a received SS7 message. If the message received cause value is filled and used to enter the table, then the cause value from that message is used in a REL from the CCM. The next function and next index point to the next table.

FIG. **18** depicts an example of the message table. This table allows the CCM to alter information in outgoing messages. Message type is used to enter the table, and it represents the outgoing standard SS7 message type. The parameter is the pertinent parameter within the outgoing SS7 message. The indexes point to various entries in the trunk group table and determine if parameters can be unchanged, omitted, or modified in the outgoing messages.

Those skilled in the art will appreciate that variations from the specific embodiments disclosed above are contemplated by the invention. The invention should not be restricted to the above embodiments, but should be measured by the following claims.

We claim:

1. A method of operating a signaling processor for a call having a signaling message and a user communication, the method comprising:

receiving the signaling message for the call indicating a called number;

processing the called number to transfer a number portability query;

receiving a number portability response indicating a route number;

processing the route number to select an identifier for routing the user communication; and

transferring a control message indicating the user communication and the identifier to a communication system, wherein the communication system, in response to the control message, adds the identifier to a header of the user communication and routes the user communication based on the identifier in the header.

2. The method of claim **1** wherein the signaling message comprises a signaling system seven message.

3. The method of claim **1** wherein the signaling message comprises an integrated services digital network message.

4. The method of claim **1** further comprising:

processing the route number from the number portability response to select a connection for routing the user communication; and

transferring another control message indicating the identifier and the connection to the communication system, wherein the communication system, in response to the other control message, routes the user communication over the connection.

5. The method of claim **1** further comprising:

receiving another signaling message for the call indicating call termination;

in response to the other signaling message, transferring another control message indicating the call termination to the communication system, wherein the communication system terminates the call in response to the other control message.

6. The method of claim **1** wherein the number portability query and the number portability response comprise signaling system seven messages.

7. The method of claim **1** further comprising processing the signaling message to select echo cancellation for the call.

8. The method of claim **1** wherein the identifier comprises an asynchronous transfer mode virtual identifier.

9. The method of claim **1** wherein the communication system receives the user communication over a DS0 connection.

10. The method of claim **1** wherein the signaling processor is not integrated with a switch central processing unit that is coupled to a switch matrix.

11. A signaling processor for a call having a signaling message and a user communication, the method comprising:

an application configured to process a called number from the signaling message to generate a number portability query, process a route number from a number portability response to select an identifier for routing the user communication, and generate a control message indicating the user communication and the identifier; and

a platform configured to receive the signaling message, transfer the number portability query, receive the number portability response, and transfer the control message to a communication system, wherein the communication system, in response to the control message, adds the identifier to a header of the user communication and routes the user communication based on the identifier in the header.

12. The signaling processor of claim **11** wherein the signaling message comprises a signaling system seven message.

13. The signaling processor of claim **11** wherein the signaling message comprises an integrated services digital network message.

14. The signaling processor of claim **11** wherein:

the application is configured to process the route number from the number portability response to select a connection for routing the user communication and generate another control message indicating the identifier and the connection; and

the platform is configured to transfer the other control message to the communication system, wherein the communication system, in response to the other control message, routes the user communication over the connection.

15. The signaling processor of claim **11** wherein:

the application is configured to generate another control message indicating call termination in response to another signaling message for the call indicating call termination;

the platform is configured to receive the other signaling message and transfer the other control message to the communication system, wherein the communication system terminates the call in response to the other control message.

16. The signaling processor of claim **11** wherein the number portability query and the number portability response comprise signaling system seven messages.

17. The signaling processor of claim **11** wherein the application is configured to process the signaling message to select echo cancellation for the call.

18. The signaling processor of claim **11** wherein the identifier comprises an asynchronous transfer mode virtual identifier.

19. The signaling processor of claim **11** wherein the communication system receives the user communication over a DS0 connection.

20. The signaling processor of claim **11** wherein the signaling processor is not integrated with a switch central processing unit that is coupled to a switch matrix.

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